

SECTION 3 — DISTURBANCES DUE TO NUTRITIONAL AND PHYSICAL CAUSES

CHAPTER 28

MALNUTRITION

IN the armed forces of a nation at war, it is necessary to keep constant watch for any signs of nutritional disturbances. Defective nutrition is not always easily diagnosed in its earliest stages, especially when due to vitamin deficiencies. Recognition of the so-called subclinical types is mainly speculative. It is obvious that many causes may be responsible for deterioration, of which food is only one, and even when demonstrable signs of disease appear it may be impossible to distinguish which are due to lack of specific balanced factors in the diet. Further, however ideal a dietary may be on paper, it may not always be translated into terms of food presented to the soldier, owing to difficulties of transport or of military conditions. Food may not be presented in a palatable or assimilable form, and its final absorption may be hindered by disease.

The story of rations in relation to the demands of nutrition is told elsewhere. Here we are concerned with the results of defective nutrition in the armed forces.

Both in Australia and in the Middle East, in 1940, the possibility of the occurrence of nutritional deficiency was raised, in spite of the adequate dietary scale.

1. NUTRITIONAL DISTURBANCES IN THE MIDDLE EAST

In Palestine during the summer of 1940, the prevalence of shallow indolent ulcers on the exposed skin surfaces raised the question of a possible deficiency of vitamin *C* in the diet. This has been dealt with in the section on dermatology. No evidence supporting such a dietary lack was brought forward at the time, but the limited observations made on this specific point, either during the 1914-1918 or the 1939-1945 war, may not yet be conclusive. "Pure" deficiencies of a single chemical constituent of a dietary are not in any case often met in clinical practice.

Apart from the occurrence of skin ulcers, some evidences of slight lowering of nutritional standards were occasionally seen in Palestine, though these were not significant. Even in the base areas some loss of weight was observed, and occasional reduction in haemoglobin, especially in members of the nursing service. Incidentally, the need for calibrating standards of haemoglobinometers was found in the Middle East, and all readings could not be taken at face value without correction.

During 1941, the lack of green vegetables was felt by the A.I.F. in some places in the Middle East. Even in base areas such shortages were felt,

even though no obvious bad results followed. In some forward medical units ascorbic acid tablets were added to the rations to make up for this lack. In Tobruk the diet was satisfactory for the greater part of the siege, despite the slender supply line, but some gaps occurred. Supplies of ascorbic acid were not consistently maintained, and the ideal advice of the hygienists concerning supplements could not be followed because of lack of certain supplies, including synthetic vitamins, in the Middle East war zone. The deterioration through time of "Marmite" as a source of the vitamin *B* complex was taken into account in its therapeutic use. Australian margarine was not in all ways satisfactory in this ration, some of it contained 10 per cent butter, but it was not reinforced with vitamins *A* and *D*, as was the English product, which was preferable. Owing to technical problems, butter could not then be transported in tins from Australia or kept under conditions of great heat without deterioration. These problems were encountered in Australia also, when, after the completion of a new road linking Adelaide with Darwin, supplies were sent to the Northern Territory by road.

Examination of Italian biscuits after the retreat of the Italian forces showed that these were a better source of thiamin than the Australian biscuits, which contained 1.93 microgrammes as against 2.5 microgrammes in the Italian product. The last mentioned was believed to be made from a superior wheat flour used for spaghetti. The Australian biscuit was not a popular success; though different manufacturers turned out from the same formulae products differing widely in taste and texture, the strain on the teeth and the unexciting flavour did not please the soldiers.

2. NUTRITIONAL INVESTIGATION IN AUSTRALIA

Meanwhile in Australia, attention was drawn by the Nutrition Committee of the Commonwealth National Health and Medical Research Council to vitamin deficiencies in Australian diets. The committee pointed out that whole meal was desirable, that more fruit and vegetables should be available, and the value of cooking potatoes in skins should be recognised. So hard is it to overcome prejudice and custom that it was still possible late in the war years to witness the unnecessary labour of peeling potatoes, even in service medical units. Current medical literature pointed out the importance of known aspects of deficiency diseases, such as those due to lack of riboflavin, and valuable research was carried out on the vitamin *B*₁ content of Australian white bread. *B*₁ was shown to be the only element of the *B* complex present to any extent in white bread. Methods of reinforcement were suggested, but objections of technical nature and of public taste were expected. It is curious how widely has spread a taste for white flour, one of the doubtful gifts of civilisation.

During the recruiting and early training in Australia of the 8th Division certain dietary deficiencies were suspected, and a small test series was investigated by the 2/9th Australian Field Ambulance. Using volunteers, a three day test of saturation with vitamin *C* was made. Though no clinical deficiency was demonstrated, a number of private soldiers, but not

officers, were found to have deficient saturation. The diet supplied at the time in camp contained too much bread, potatoes and flour, and not enough fruit, milk and greens. Normal leave period allowed most of the men to supplement the camp diet. This experiment was on a small scale, but in December 1940, the Director-General of Health informed the D.G.M.S. that the nutrition committee recommended that the vitamin C saturation of soldiers should be investigated in each command. The technique adopted was to test the urine for ascorbic acid, then to administer 300 milligrammes of ascorbic acid, and repeat the test four hours later. The results showed that saturation was by no means constant. In the Northern Command, for example, only one-third of the troops were in a condition of vitamin C saturation. Later in the Northern Territory the D.D.M.S. of that area warned of the possibility of a vitamin C deficiency there. A suggestion was also made of a connection between vitamin C deficiency and gingivitis, but no convincing evidence was produced. Vitamin deficiencies were seen sometimes in natives in the northern parts of Queensland and other more isolated parts of Australia, but the troops in these parts in practically every case had no trouble.

The Council for Scientific and Industrial Research (Division of Food Preservation and Transport) carried out experimental work on the supply of vitamin C for defence purposes. Lists were compiled for Australian use, setting out the concentration of ascorbic acid in local foodstuffs. Difficulties were encountered in producing fruit juices without loss of the vitamin content, by reason of intrinsic drawbacks to such processes as spray drying, want of correctly lacquered tinplate containers, and loss of flavour.

This interest in vitamin C was of value, as it laid emphasis again on the need for fresh fruit and vegetables, though it was not easy to translate this into terms of achievement. This difficulty was sometimes a real one in revictualling ships of the Royal Australian Navy, especially in some ports, where sufficient supplies of fresh food could not be obtained. In December 1941, for example, H.M.A.S. *Westralia* was unable to get good meat or fresh or tinned fruit in any quantity in Darwin. Investigation showed that twenty-four out of twenty-nine ratings had a deficient reserve of vitamin C. As will be told presently, gardens alleviated such shortages to some extent, though in great areas like Northern Territory the transport difficulty was considerable. At a later period, in June 1943, naval ratings admitted to the naval hospital at Darwin were found to present some signs of avitaminosis. Though efforts were constantly made to supply fresh vegetables, fruit and milk to ships' companies, criticisms were levelled at the slight margin of vitamin C available. The daily issue of lime juice was sometimes the only source, but tomato juice was also supplied. Issue lime juice had little antiscorbutic value, and it was suggested by one medical officer that a drink might be made from dehydrated lemon juice, corn syrup and ascorbic acid. When the diet as presented to the army and air force sometimes consisted chiefly of meat and potatoes, with only a small amount of powdered milk and cheese, there must also have been

temporary shortage of calcium and vitamin *B*. At the Darwin naval station, within a year some six cases were seen in ratings of oral lesions believed to be due to riboflavin deficiency. Several medical officers considered that certain symptoms were due to "subclinical" avitaminosis, such as headache, anorexia, dizziness and slight muscular tremors. No accurate studies were made, but response to a more balanced diet was observed, and it is possible that there was a nutritional basis.

One instance of inaccurate statement should be mentioned, as an indication of what harm this may do. A report emanated from an investigator in Adelaide who was working on methods of packing cabbage in tin plate so as to preserve its content of vitamin *C*. This reached Washington in the form of a rumour that a serious outbreak of scurvy had occurred both in the Northern Territory of Australia and the islands, affecting a large proportion of men. This was completely untrue, as only two instances of malnutrition owing to lack of ascorbic acid had been found in the Australian armed forces at that period. Other exaggerated statements were made from time to time, and some were published, but their basis was always very slender, and usually non-existent.

The abnormal factors in the local food problems of the Northern Territory and New Guinea were recognised, particularly with regard to fresh foods. Where civilians could not be employed in certain areas because of their declaration as operational zones, and therefore supply by contract was impossible, the joint needs of the Australian forces and later the British and American forces in the South-West Pacific Area, together with those of civilians, exceeded Australia's productive capacity for fresh foodstuffs. Therefore coordination of requirements was effected under the Department of Commerce and Agriculture, and in the special areas mentioned, farm companies were organised under the Australian Army Service Corps. These were most successful projects, and provided fresh foods for the Services, saved transport and refrigeration space, and reduced cost as well. In the various internment camps in Australia, also, extensive gardens were maintained by the use of voluntary labour of prisoners, and the production of supplies greatly in excess of local needs, other sources being thereby supplemented. These measures lessened the monotony of tinned and dehydrated food, and the coincident efforts of the Catering Corps to improve the preparation and economical handling of food, helped to feed the men doing the jobs of war. The development of farm units in Northern Territory, Central Australia, Queensland, Cape York Peninsula, New Guinea, New Britain and Solomon Islands under control of the Directorate of Supply and Transport undoubtedly had a far-reaching effect on the health of troops.

Refrigeration was an important matter too, particularly with the expansion of service requirements for the defence of Australia. Late in 1939 the Military Board recommended that power refrigerators should be installed at camps throughout Australia. Though business advisers were at first opposed to this, and suggested the use of drip safes and ice chests, expert opinion stressed the much greater efficiency of powered units. Stan-

dard units of robust construction were eventually supplied, simple to maintain and to move. Though at first the army relied on Red Cross gifts of refrigerators to keep essential medical supplies such as antisera at the proper temperature, refrigeration won its recognition as an essential requirement wherever it could be installed, especially in tropical areas.

One matter related to environmental conditions in the tropics is the salt and water requirements of the soldier. This was seriously considered in the Middle East, and reinforcement of drinking water under working conditions of intense heat was sometimes used. This is referred to also in the section dealing with environment. Salt tablets were provided in the islands, containing crystalline table salt with a prescribed content of calcium and magnesium salts.

A practical trial of methods in the field was made in 1942 under the supervision of Lieut-Colonel Sir Stanton Hicks, Chief Inspector of Army Catering. He had pointed out that fresh food supplements were necessary in the Northern Territory, and that special convoys were needed to maintain the protective value of food. In the north-western part of Australia in 1942-1943 a special independent group and a guerilla warfare group were used to study problems of feeding. At one time these troops had eaten from tins, with no fresh supplements; their health was not good, and sores on the skin were common. When wheat and blue peas were made available, using the germination method as used by Captain Cook, together with yeast, bread of 60 per cent whole meal and tablets of lucerne and ascorbic acid, the troubles all vanished. These men were able to maintain health and vigour and to be independent under exacting conditions.

On the whole, servicemen in Australia maintained a satisfactory grade of nutrition. An occasional instance of mild deficiency was seen, of the type not uncommon in civil practice, caused by a combination of unwise selection of food and infective illness. In the Base Military Hospital in Perth, Western Australia, six mild cases of deficiency were reported in some four months, two being in civilians; two patients showed glossitis and cheilitis, and the others corneal vascularisation, anorexia, some oedema, and lessened response to effort.

Men returning from New Guinea or Timor in 1943, who had lived under extremely trying conditions, sometimes being forced to subsist on the country unaided, often showed signs of malnutrition, and vitamin supplements were needed in their treatment, when admitted to hospitals in Queensland. In the Northern Territory a few patients with mild *B1* vitamin deficiency were seen. One interesting feature there was that on the few occasions when symptoms of deficiency appeared, they were of the nature of a neuropathy, and lesions of the tongue and mouth were infrequent. It will be seen presently that in 1943 the opposite was found in New Guinea.

In 1943, a medical officer was appointed to the staff of the Medical Directorate to act as liaison officer to "Q" branch (Nutrition) of the army. Surveys of local conditions in all areas were made, and studies carried out on the food pattern preferred by the Australians on service.

Information was obtained as to the acceptability of various foods. "Bully" beef was still a favoured and staple source of protein, but where air transport was possible, frozen boned beef met with great success. Dehydrated mutton was not successful and was given up. Dehydrated eggs required an enlightened cook, and survived their first bad reputation when methods of production improved. Dehydrated vegetables varied in acceptability. "Goldfish", the unpopular tinned herrings and pilchards, were disliked in New Guinea as much as in the Middle East. They were simply unacceptable to most servicemen, although civilians deprived of tinned fish welcomed an occasional tin as a change from their own often dull ration. It may be noted in passing that civilians in the northern States in 1942-1945 were worse off for varied food rations than in the southern States, owing to the demands of the forces in the north and the better manufacturing and distributing facilities in the south.

The value of all the effort and research expended on the subject of food, in all its aspects, was of course not only in its reflection on the well-being of the fighting soldier and all those behind him, but also in its prophylactic importance. Without this care malnutrition might have been a great danger, especially to troops or civilians exposed to fatigue and hardship. The importance of these factors will be stressed as this account proceeds. Many examples might be quoted. For instance, after the Italian defeat, some of the Italian prisoners of war in Egypt showed signs of pellagra. The effect of the hard days of defeat with poor and insufficient rations was later evidenced in men captured by the Germans in Greece. The latter were not so fortunate as the Italian prisoners, whose symptoms were quickly relieved by yeast.

3. *NUTRITIONAL DEFICIENCIES IN THE PACIFIC ISLANDS*

In island warfare conditions of feeding were made more difficult because of uncertainties of transport by arduous and complicated routes; particularly trying were the last laps of these journeys to landing points and thence to forward units. Dropping from the air was used considerably in New Guinea, and in spite of an unavoidable wastage rate, it was a successful, and sometimes the only practicable, method.

An intrinsic weakness in the distribution of rations was that the innate selfishness of man intrudes: the temptation to abstract the more popular and varied items and to pass the remainder to those beyond was not always resisted, despite the greater needs of the forward troops. The introduction of the individual forward operational ration overcame this. This ration was palatable, easily consumed and self-contained. Perhaps it met too completely the desire for sweet food so common among Australians serving in the varied climates of New Guinea, and the men tired of it, but it had many advantages. Scientifically perhaps, the accuracy of some of the descriptive labels on parts of these packs could be questioned. Perhaps for propaganda it is justifiable to inform the soldier that a food

contains vitamin *A* which "increases resistance to common diseases" even though the truth of the statement may be questioned.

In December 1942 it became evident that the force in Milne Bay which had been irregularly served by sea transport was receiving a very unsatisfactory diet of low vitamin content. No refrigeration was then available. The men were heavily infected with malignant malaria. The medical services pointed out that there was grave risk of deficiency disease on a wide scale unless adequate quantities of protective foods were sent straight-away. Medical comforts for hospitals, containing additional sources of vitamins were listed, and action was taken to improve conditions. The Deputy Assistant Director of Hygiene of New Guinea expressed the opinion in 1943, that poor diet was a contributory factor to the high incidence of malaria. Many were receiving a diet notably deficient in vitamin *B* complex. The chief dietary need at the time was an adequate ration actually reaching the men, and where this was not possible an issue of vitamin capsules for front line fighters was suggested. Brigadier Disher, D.D.M.S., New Guinea Force, noted too that the nearer the front line the poorer were the rations; here bully beef and biscuits were too often the staples. The ratio of sick to wounded of the 7th Division in hospital was 7 to 1 with active fighting going on between Kokoda and Buna. The men returning from the Kokoda trail were not only fatigued and worn out by the hard conditions and disease, but by subnutrition as well.

At this time, too, the danger of beriberi in native carriers was recognised, and occasional instances were seen. Precautions were taken to ensure adequate diets for these men, at the instance of the medical advisers in New Guinea, and stress laid on the risks of polished rice. There were then only 60 pounds of "Marmite" on the island, and no substitutes were to hand. This was needed particularly for these native carriers, and was dropped from the air to forward posts.

When the stress of the first New Guinea campaign was over and supplies could be more easily obtained, the general standard of health improved. This could be seen in the troops, whether resting, in active work or in hospital, even though more of them had declared evidence of specific deficiency states. During 1943, the less rushed nature of work in the medical units in New Guinea gave opportunity to more detailed study of the problems of nutrition. The vitamin *B* complex in relation to clinical syndromes owing to lack of some of its components aroused special interest.

The position with regard to *B1* deficiency could easily have been confused, possibly it was at times, for polyneuritis in localised forms was not uncommon in men whose nutrition was quite satisfactory. It is of course possible that neurons might withstand the assault of a neurotropic virus less well if protective substances were lacking in the diet and therefore in the tissues. There was no doubt that occasional instances of *B1* deficiency of the neuritic type were seen as well as polyneuritis. The combination of oedema, even if slight, muscular weakness and sensory disturbances, was sufficiently definite for diagnosis. However, a diagnosis of *B1* deficiency was made without warrant on occasion, on the slender and

inconclusive evidence of subjective sensory changes. A technical instruction was issued in the army directing the attention of medical officers to the findings of physicians in a semi-forward area; this described a syndrome of deterioration of health and stamina, combined with analgesia to pin prick on the extremities. As might be expected, sensory changes became rather a popular symptom and after critical review of a test series with controls, the instruction was withdrawn and replaced by another laying down more rigid standards. These included decreased or absent tendon reflexes, weakness of muscles, as shown by failure to perform the squatting test, pareses or paralyses. Foot drop and hand drop if present formed part of a progressive picture. General signs of malnutrition were to some extent confirmatory, so too was oedema of the legs. Sensory changes were reliable only if established beyond doubt, and included paraesthesiae, hyperaesthesia or proven sensory loss. There is no doubt that some of the sensory phenomena in earlier groups of men were largely of hysterical origin.

Further examples of this will be given later. No serious syndromes, such as cardiac beriberi, appeared.

In general, though malnutrition was seen during the early strenuous periods in New Guinea, clear cut pictures of specific avitaminosis were very uncommon.

At a hospital in Moresby, only a small number of undoubted instances were seen, and these were mild in nature, the men seldom showing more than pre-tibial oedema, diminished tendon reflexes, anorexia and debility. As an empirical measure thiamin tablets were given for 7 to 10 days to all men who had been long exposed to bad jungle conditions. Such men had usually been in patrols away from main bodies of troops. The medical advisers of New Guinea Force stated late in 1942 that patrols, commandos and watchers needed supplementary rations.

In 1943, the catering corps early began to demonstrate methods of attaining a sufficient supply of vitamins, especially the *B* complex. Measures specially advised were the fortification of bread and the use of dehydrated butter and germinated blue peas. Perhaps on the clinical side too much emphasis was laid on the importance of the *B*₁ part of the *B* complex. On the one hand the soldiers' dietary must give him confidence; on the other hand watch must be kept for the appearance of the earliest signs of deficiency after a latent period, and the signs usually attributed to lack of thiamin are manifest soon after a term of poor diet. Early in 1943, however, signs of another kind were recognised. At the 2/5th Australian General Hospital men were seen with lesions of the mouth and tongue in addition to mild neuritic affections.

Treatment with thiamin, nicotinic acid and "Marmite" in addition to full diet, soon relieved all these conditions, and in 6 to 8 weeks dulled or absent deep reflexes were active and full muscular power had returned. A search through the wards revealed an unsuspected group of ten men with fissuring of the angles of the mouth, and in some, denudation of the tongue with painful margins. They recovered promptly on treatment. Com-

parison of the diets of these men while in forward areas with the diets of a control series showed the following shortages. Calories consumed averaged 2,800 per day, the full requirement being 4,500; protein, fat and carbohydrate were adequate and proportionate, but vitamin *C* was deficient (4 milligrammes or less a day of ascorbic acid), and vitamin *B* complex was assessed at 160 to 400 I.U. a day, though the metabolic requirements in a tropical zone were at least 800 I.U. per day.

It is fair to state that defects in the rations of men in operational areas were owing to a failure of full supplies to reach them, not because of an intrinsically defective dietary scale, but through extreme difficulties of transport. Changes in the military situation and improvements in the food supplied promptly removed the risk of further deficiencies of vitamin *B*₂ revealed in this small series. Lieut-Colonel Dods pointed out that patients of this type would recover readily while at rest in hospital without further treatment, as the patients' dietary in the 2/5th A.G.H. in the Moresby area was at that time estimated to contain 3,000-4,000 Calories, protein 1 to 2 gramme per kilogramme body weight, vitamin *A* 10,000 to 30,000 units, vitamin *B* 700-1,000 units and vitamin *C* 100 to 200 milligrammes daily.

Major Rose, in a report on vitamin deficiencies in New Guinea, covered the period from Christmas 1941 to March 1944. In the early part of this period all troops were in the Moresby base area, and no sign of food deficiency was seen. During 1942, 180 men and a few women and children were rescued from the Jacquinot Bay area some three months after the fall of Rabaul. Almost all of these survivors had malaria and diarrhoea. They had fed on vegetables only, with the rare addition of a very little meat. Many of them had general oedema, but even so they had on the average lost some two stone weight. The oedema was, of course, famine oedema, though estimations of protein in the blood could not then be made; the response to thiamin, even in large parenteral doses, was negligible. Most of these people also had sore and atrophic tongues.

Similarly affected were men in one group who returned after the Kokoda action. A number of men of the 2/27th Battalion, cut off in the bush behind Nauro, had oedema which subsided in some six weeks. Some of these had diarrhoea which would not yield to standard measures, including sulphaguanidine. Their tongues were atrophic and occasionally sore, and on a regime of nicotinic acid and "Marmite" they rapidly recovered. They undoubtedly had some symptom of pellagra. Another group of men from the 2/14th, 2/16th and 39th Battalions had neuritic symptoms. The deep reflexes in the legs were either exaggerated or almost absent, and they suffered from burning pain in the feet. On full diet with extra thiamin they recovered only slowly, but the addition of "Marmite" quickly relieved them. This group appearance of deficiencies of various components of the *B* complex is to be specially noted, for it was found to be a feature of the unhappy experiences of the 8th Division in captivity.

From "Kanga Force" in the Wau area a large number of men were sent to hospital with a diagnosis of beriberi. Analgesia was common; it

was noted over a wide area of body surface, but with no relation to the established pattern. Sluggish reflexes were frequent; so too was slight oedema of the ankles. These men had recurrent malaria and had been on a low diet for some time; but the diagnosis was questioned in hospital, especially as the more reliable sign of tenderness of the calf muscles was absent. This opinion was confirmed by the arrival of men of the 17th Brigade who, though in the area only six weeks, complained of the same insensibility to pain. Some genuine, though mild examples of deficiency states, were seen from the Wau sector, where hardship had been suffered, but the symptoms were much exaggerated, and in some men they were feigned; the existence of mass hysteria was further confirmed by magic cures wrought by injections of sterile saline, or merely by unaided suggestion. By contrast, one of the curiosities of this period was a man who had worked for over a year in a bakehouse in Moresby town area, and who had genuine neuritic beriberi.

About the same time, an increased number of men from the Moresby base area were found while under the treatment for malaria or other infection, to have angular stomatitis, cheilosis and glossitis. Symptoms were relieved by "Marmite" taken for 5 to 6 days, though recurrences were frequent. A suggestion made at the time was that a chemical incompatibility existed between riboflavin and atebirin, which was then being taken in suppressive doses. No evidence of this was found in other campaigns. Later, the men coming through Lae from the Ramu Valley and Finschhafen campaigns not infrequently showed these lesions, though other signs of deficiency were absent.

No scurvy was seen, nor any sign of the toad-skin manifestation of vitamin *A* deficiency. There were, however, occasional instances of scrotal dermatitis among men with other evidences of lack of riboflavin, but the full significance of this was not realised at the time.

The later years of the island campaigns added no new experiences in deficiency diseases. In 1944 and 1945, occasional examples of thiamin deficiency were seen, for instance among the Chinese at Madang and Yalu who had been in Japanese hands, and who improved rapidly on thiamin. In general thiamin deficiency was not at all common in the islands; mild manifestations of *B* complex deficiency were more frequently seen. Single deficiencies were rare, and malnutrition, combined with fatigue, appeared in many variants, depending to some extent on the different metabolic characteristics of individuals. In the island campaigns correct rationing, efficient delivery and preparation of food and careful medical supervision prevented malnutrition from being a serious waster of men.

4. NUTRITIONAL DISTURBANCES IN PRISON CAMPS IN EUROPE

Experience has shown that prisoners of war may arrive in prison camps in a state of poor nutrition if they have passed through previous stages of siege, retreat and disorganisation followed by exhausting journeys with

poor and insufficient rations. To this, add the effects of the anorexia of mental depression and the likelihood of confused organisation of and in the camps, with the difficulties of commissariat, transport and language, and disorders of nutrition may easily be produced. Where the prisoners' rations were ill-balanced and meagre, as too often they were in the experience of our own captured troops, the risk of deficiency disease was considerable. In certain prisoner-of-war camps in Italy and Germany well-defined deficiency states were recognised.

(a) *IN ITALY*

In Gruppignano, No. 57 in Italy, during the first part of 1943, bad conditions were encountered. Lack of sufficient or proper food was responsible for beriberi and other deficiency states mainly among men captured in Egypt and Libya during 1942. The concentration camp there was not properly organised and many men arrived at the European camp exhausted. The diet consisted of small quantities of stew or macaroni soup, with very little meat, and 100 grammes of bread. Some help was obtained from Red Cross parcels and a little from canteens. R. T. Binns and E. W. Levings both described beriberi in this camp. Some of the men from the desert fighting of 1942 were seriously ill, and a few died. Relief was difficult to give them, as the commandant refused to allow the use of invalid supplies held in the stores.

(b) *IN GERMANY*

Lieut-Colonel Le Soeuf (C.O. of the 2/7th Australian Field Ambulance) reported conditions as very bad in some camps. For example, in Crete, prisoner-of-war camps were allotted a diet chiefly composed of carbohydrate. At first the food was quite adequate, and after the first month or two a temporary supplement of fresh vegetables was supplied, but the sick were dependent mainly on the charity of the poor local Cretans, who gave them small quantities of milk and eggs. The diet was only of 1,400 Calories and some beriberi occurred here.

In Salonika famine oedema occurred in some prisoners; in Germany the dietaries varied greatly in different camps. In 1942 and 1943 there was a noticeable lack of protein, and in Dulag 183, for instance, the Australians arrived to find over 200 cases of famine oedema in hospital. The British prisoners received a starvation ration, apparently as part of deliberate policy. The German Military Authority claimed that the ration would have been increased but Red Cross food was available; nonetheless, during the periods when no Red Cross supplements were to hand no increase in the ration was made. Sometimes Red Cross stores were refused to men with oedema due to deficiency.

In Oflag 79, the diet was supposed to contain 55 grammes of protein and 1,800 Calories, but it did not, and oedema occurred in the men. The caloric value was reckoned to be 1,324, and the protein, totalling 46 grammes, contained only 7.1 grammes of first class protein. After some months on the German rations, officers at this camp noticed swelling of

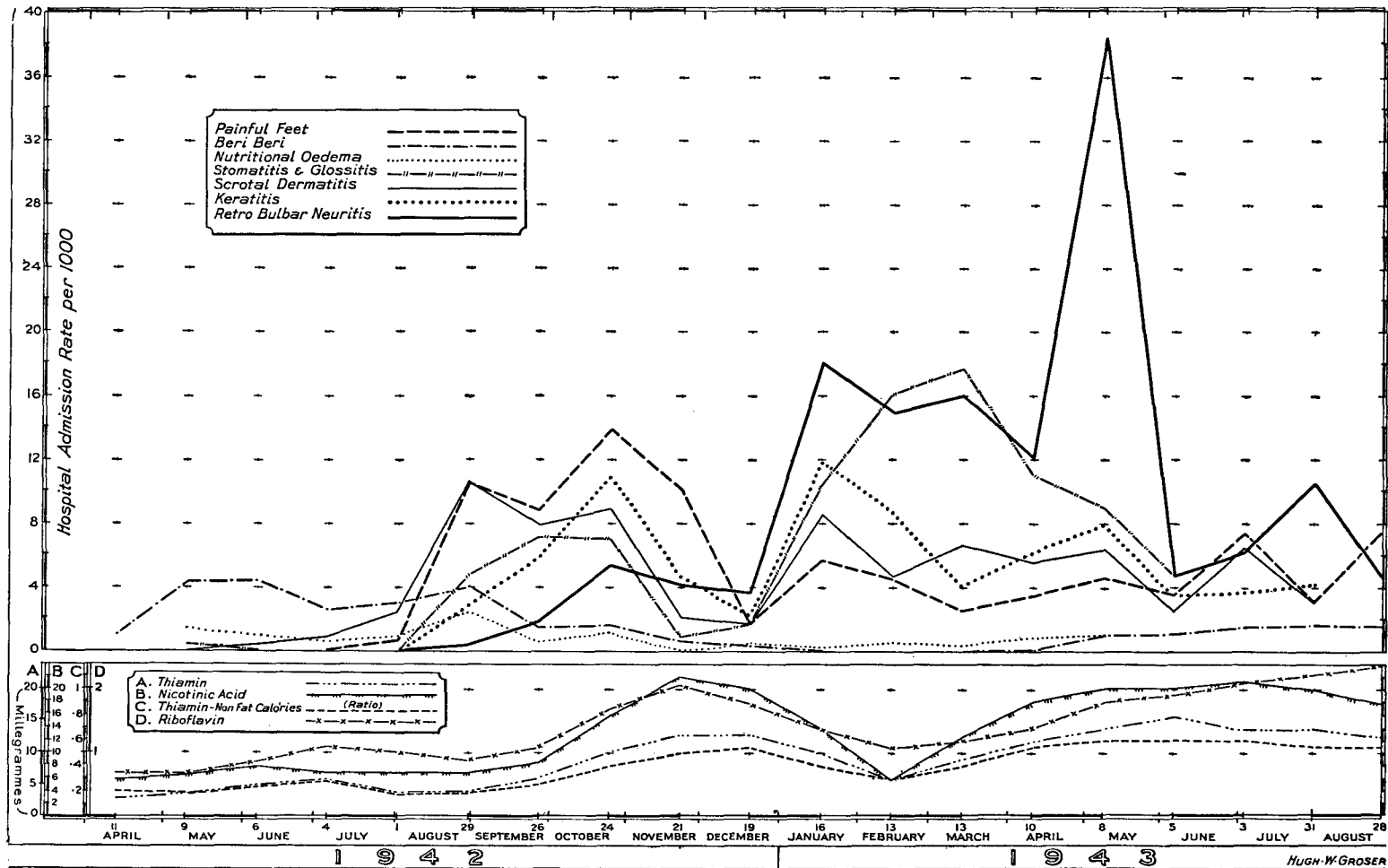
the feet and face. Two weeks after a delay in arrival of Red Cross food, general oedema and shortness of breath were observed, relieved later by an increase in the protein ration.

In March 1945 in a report on the camp conditions, Le Souef stated that there was gross undernourishment in the camp. At this date the ration given by the Germans to British and American officers contained 46 grammes of protein, 22 of fat and 233 of carbohydrate.

5. NUTRITIONAL DISTURBANCES IN PRISON CAMPS UNDER THE JAPANESE OCCUPATION

In a clinical account we are not directly concerned with administrative detail. Yet in describing the inroads of disease on the prisoners of war who fell into Japanese hands the effects of cruelty and neglect cannot be disregarded. With a curious lack of insight, and disregarding the greater working capacity of men given reasonable accommodation and nutrition, the Japanese wasted this labour force and allowed nutritional and infective diseases to kill the prisoners in thousands. Without the firm united stand and incessant struggles for better conditions by all concerned in the Allied forces, the results would have been even more tragic. The burden cast on the medical services was tremendous. Amidst all their labours they yet found time to record the clinical conditions of men with disorders of malnutrition, and this account of the medical scientific aspects of diseased states, largely owing to gross deficiencies of diet, is based on a series of carefully prepared reports, clinical accounts and diaries, mostly written in captivity and concealed till the day of liberation. Many of these are of high medical value in their own right, and in them the members of the medical services of the 8th Division tell their own story. The considerable space given to these descriptions is owing not only to their clinical worth but also to the sad fact that circumstances permitted an unusual experience which has some scientific value. To bring clinical pictures into relation with clear-cut dietary defects is always scientifically difficult and often untrustworthy. No such attempt is made here. The accounts stand on a basis of factual observation, with such suggestions about possible causes as may emerge from the story. They follow roughly the order in which they appeared in Changi, where continuous medical work went on for the whole period, and where good consecutive records were successfully kept, largely owing to the Acting A.D.M.S., Lieut-Colonel J. Glyn White. The order is therefore of chronological significance, which is pointed out by the chart constructed and kept at Changi.

After the capitulation in February 1942 it was evident that the Japanese ration scale was inadequate (Appendix 1) and a week's ration was issued to the troops from a six months' store held by the British forces. The chance of getting such necessary supplements such as meat and butter was slender, for they would have to be shipped to Malaya even if the Japanese would supply them. On the 10th March, Colonel A. P. Derham (A.D.M.S. 8th Division) gave a warning of the results of the

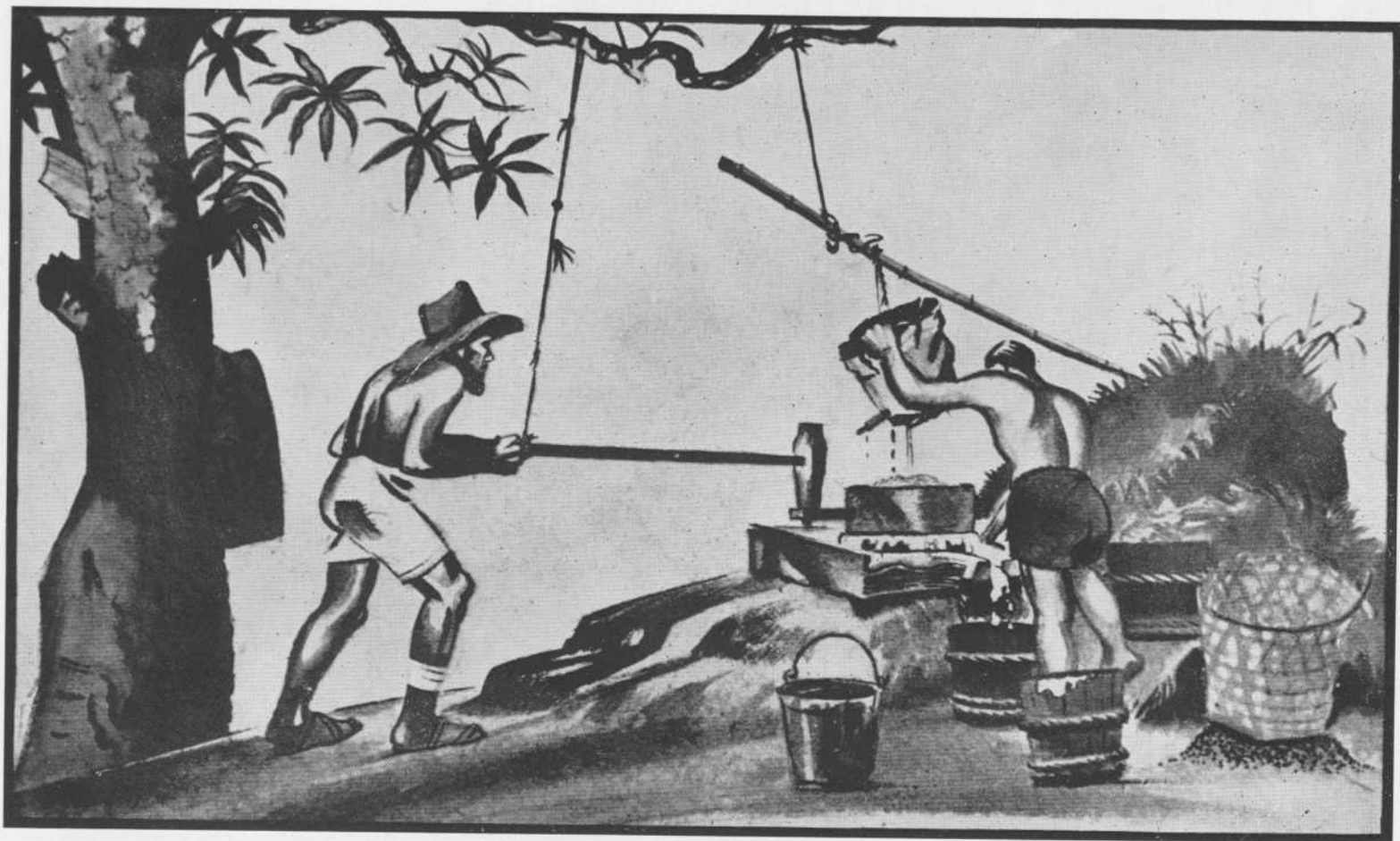


Incidence of clinical syndromes of malnutrition in Changi. (Drawn in Changi by Lieut. R. M. B. Strawbridge, R.A.E.)

proposed dietary scale and on the 15th, Brigadier Stringer (D.D.M.S.) prepared a letter sent by the G.O.C. Malaya to the Japanese Army commander pointing out the inadequacy of the diet, but without result. A nutrition officer (Major Burgess, R.A.M.C.) was appointed, and some months later a Nutritional Advisory Committee, on which the A.I.F. had representation. In March, beriberi had begun to appear in the forces in the Changi area, and by August, rapidly growing numbers of cases of deficiencies, chiefly due to lack of vitamins of the *B* complex had reached a peak. It is of interest to note that the Australians at first showed a higher incidence of these diseases; early in September 1942, 27 per cent of the British soldiers in hospital had deficiency diseases, but 42 per cent of the Australians in hospital. Little impression was made on the Japanese Army by repeated strong representations for dietary supplements, particularly rice polishings, soya and towgay (sprouted dhal), even though the figures were based on modern dietary tables drawn up by experts long resident in Malaya. Fortunately, the medical services of the forces had collectively an adequate library of medical scientific books and literature. Of course the necessity for the combined forces to help themselves was clearly recognised and from early days organisation was directed towards the buying, collecting and growing of fresh supplements of vegetables and other food, and those aspects of scientific research which would supply some of the much needed material of all kinds. By the later part of 1942, the A.I.F. services were producing an extract to supply extra vitamins of the *B* complex.

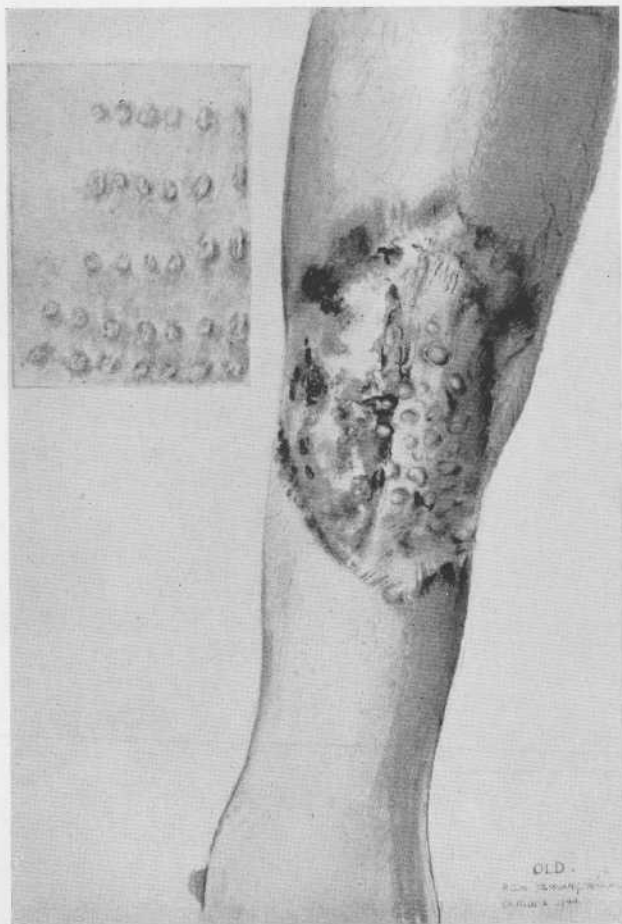
At first, with some reserves to fall back on and some Red Cross stores for use in the hospital, the nutritional state of the men, though showing some deterioration, was fair, considering the stress of the previous period of military action. Soon, however, the results of sub-standard feeding became evident, and with the added malign influence of dysentery, diphtheria, malaria and other infections, the numbers of deficiency states increased rapidly. By August, 10 per cent of the men in hospital had beriberi.

By the end of 1942, deficiency diseases of all kinds were common. Naturally, the incidence of these fell most heavily on the men employed in working parties. Some of the working camps were very bad indeed; disease raged in them and many men died. In others the conditions were less bad; they depended largely on the attitude of the Japanese commandants whose rank, experience and treatment of prisoners varied greatly. Some of these camps were relatively near the central concentration area in Changi, on Singapore Island, others stretched out in a long chain to Burma, Thailand, the Netherlands East Indies and Japan. Diets varied in each camp, and the amount of each foodstuff supplied daily was frequently well below the amount promised. Protests were in vain. Alterations in local rules, such as the institution of different scales for heavy workers, light workers and non-workers introduced imbalance more flagrant than ever. Non-workers included patients, so that a man who would be made more efficient by hospital treatment had his chance of speedy recovery

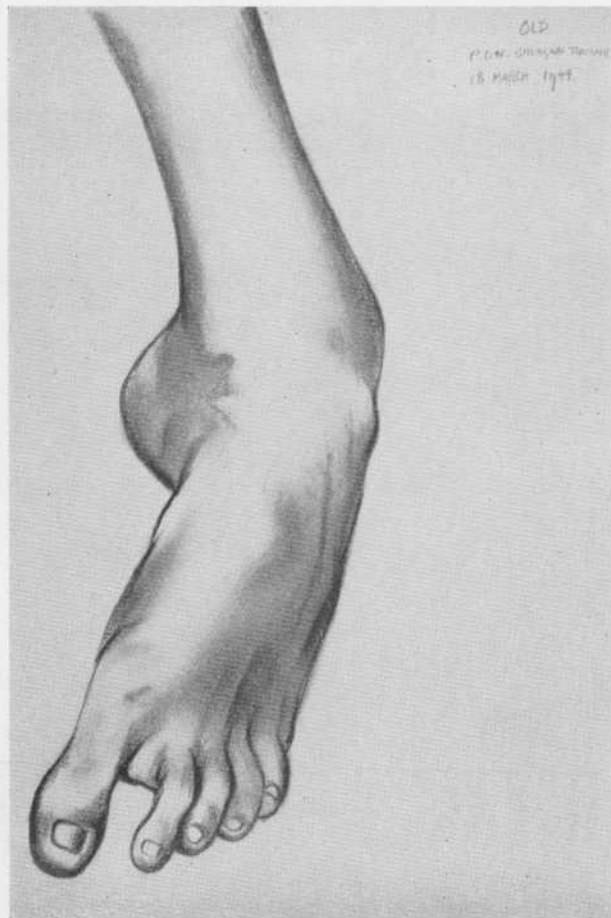


Milk from soya beans, P.O.W. camp, Tamuang.

(Drawn by A. G. Old)



(Drawn by A. G. Old)
Tropical ulcer—healing with skin grafting after excision.



(Drawn by A. G. Old)
Foot drop—neuritic beriberi.

reduced. It was often better for him to keep out of hospital, at the cost of his health. The following table contrasts the diets received for "light" and "heavy" workers in April 1944, and also shows the actual issues:

Item	Light duty Grammes	Heavy duty Grammes	Actual camp issue Grammes
Rice	265	400	275
Beans or maize	135	200	130
Vegetables	400	600	as received
Fresh meat or fish or	50	100	as received
Preserved or dried fish	25	50	as received
Sugar	20	20	18
Salt	20	20	17
Oil	25	25	25
Tea	5	5	4
Pepper	20	20	20

It was clearly the duty of the medical services to circumvent orders which inhumanly gave little chance of recovery to sick men; this they did by a system of pooling and when inspections frustrated this, by using repeated feedings. Dietary supplements were bought whenever possible, funds derived from officers' pay, N.C.O.s' pay and the pay of the working parties being used. Purchasing value fell off and prices rose steeply as the years went on. Red Cross parcels and other supplies when available helped to eke out the meagre ration, and for a time also, a loan of money from the Singapore representative of the International Red Cross helped greatly. Gardens were permitted and encouraged by the Japanese in the fixed camps, but the products were reckoned as part of the ration. Further complications in feeding were introduced by the constant movement of working parties. This affected arrangements in the Changi area considerably, especially when sick and weakened men returned from the sadly depleted working parties on the Burma-Thailand railway.

Special attention was given to hospital diets, especially in the fixed and semi-fixed centres. Supplements by local purchase were used, and eggs were bought from natives through a canteen, as long as this was permitted, or through an unofficial black market or from private owners of poultry. Poultry was also kept by some of the medical units with the help of the Japanese. The blessing of Red Cross parcels was applied to the amelioration of diets of men with debilitating acute or chronic disease, such as tuberculosis.

Certain periods and episodes during the weary years were highly significant with regard to deficiency diseases. Various syndromes were encountered in the early period of 1942-1943 when different clinical states due to malnutrition appeared in serial order. In the middle period, 1944, numbers of men had apparently contrived to exist with a lowered metabolism, though with a balance held precariously. This was due partly to loss of weight, which was usually substantial, but, whatever the cause, the incidence of nutritional disease at this later date was different both in

degree and character. In the final phase in 1945, conditions again became very bad, disease running a grim race with the prospects of relief by arms.

One of the striking features of the incidence of deficiency disease syndromes was their serial appearance. Thus various clinical pictures appeared in turn, overlapping to some extent in point of time, but really providing a series of epidemics which varied in nature and waxed and waned according to dietary changes and other more or less subtle metabolic influences. This epidemic feature of deficiency disease seen *en masse* is well known. At least it gave the medical officers an opportunity of studying the characters of each syndrome, and gathering information as its cause and its relief. This opportunity they seized fully and the knowledge thus gained was pooled. Full use was made also of the experience of medical officers attached to various components of the force on Singapore Island who were specially skilled in problems of tropical nutrition. A committee of physicians from the A.I.F. was formed to consider methods of investigation and treatment, and by November 1942 general agreement had been established among all physicians in the area as to the value of certain therapeutic measures. Opportunity was also given to individual medical officers to make intensive study of limited fields. Some discussion went on concerning the desirability of the use of control services in the assessment of methods of treatment, but the view of A.I.F. headquarters was that comparison of degrees of success attending various measures would be beneficial to knowledge and to the patients themselves.

Historically it is clearest to consider the symptom complexes as they appeared in the Changi hospital area, which drew patients from a fairly wide zone, including base troops and working parties on the island and neighbouring parts of the peninsula. A purely symptomatic classification was adopted officially there, with simple code letters to secure uniformity of description. A medical officer, Captain M. Woodruff, was appointed to coordinate the statistical side of therapeutic research, which was of course also valuable from the preventive side. The descriptive list included the following: burning hands, painful feet, encephalopathy, spastic paraplegia, peripheral neuritis (neuritic beriberi), cardiac beriberi, nutritional oedema, stomatitis and glossitis, buccal ulcers and palatal erythema, scrotal dermatitis, pellagroid lesions of the skin, tropical ulcers, keratitis (granular cornea) and deficiency amblyopia (the so-called retrobulbar neuritis). This does not represent the order of the appearance of these conditions in Changi. Deafness due to dietetic deficiency may be added, and the special variety of cardiac emergency which caused cardiac arrest and in most instances sudden death ("*shoshin*"). Later a fresh syndrome appeared, in which severe ulceration of the throat occurred, usually associated with neutropenia; this was called the "new syndrome" for purposes of discussion.

Certain clinical categories may be chosen as headings for descriptive purposes, and these will be discussed more or less in the order of their appearance, and as far as possible those believed to be of related aetiology will be bracketed. It will be realised that many, if not most, patients suffered

from several simultaneous deficiency states, and also from acute or chronic infections. The balance was always delicate, and an infection or an alteration of the ration consumed or absorbed, such as for example, excess of carbohydrate, could easily tip a patient from precarious equilibrium to frank deficiency disease. Deaths from dysentery, diphtheria, malaria or tropical ulcers were nearly always due in part to coincident malnutrition and deficiency disease. This was particularly so in the working camps, especially those in Burma and Thailand, where sick men were so often constrained to work. In Tamarkan, for example, in 1944, some 50 men suffered loss of a leg because of deep tropical ulcers, whose extensive nature was due largely to poor nutrition.

The times of appearance of the chief symptom complexes and period of their highest incidence and greatest intensity have been shown in the diagram on page 327. Cotter Harvey's table shown as Appendix 2 also sets out the average analyses of dietaries over the period of the Japanese occupation.

THE CLINICAL SYNDROMES

A. BERIBERI

The first sign of beriberi appeared within some six weeks of the capitulation. This had already been forecast by the medical advisers of the forces, by reason of the extremely poor dietary allowed by the Japanese Army. The first cases were seen in April among British troops. The type seen then was chiefly neuritic, and oedema was also found in some. Aids to treatment were insufficient and unsatisfactory, although a supply of vitamin B1 tablets was obtained from the Japanese. Later rice polishings were obtained as a dietary supplement.

By May 1942 the prisoners were suffering from loss of weight and energy, and the sick wastage had risen to 4.07 per 1,000 per day, a not inconsiderable figure in a force nearly 15,000 strong. There was urgent need for adequate protein and vitamins; even with such Red Cross supplies as were available the diet was deficient as shown in the accompanying table:

May 1942	
Carbohydrate	458 gms.
Protein	47 gms.
Fat	18 gms.
Calories	2,182
Non-fat calories	2,076
Calcium	0.127 gm.
Phosphorus	1.002 gms.
Vitamin A	231 I.U.
Vitamin B1	564.3 microgrammes
Vitamin C	2.5 mgms.
Riboflavin	0.879 mgm.
Nicotinic acid	7.625 mgms.
Thiamin/Non-fat calorie ratio	0.273

Some additions were obtained, bringing up the caloric value of the diet, raising the thiamin non-fat calorie ratio above the danger level, and

supplying less meagre amounts of the other elements of the *B* complex. It is difficult to assess the intake of thiamin and to correlate this with the onset of beriberi. The amounts taken varied, and probably even more so, the amounts absorbed. The optimum for men working in a hot tropical climate has been stated as not less than 500-600 international units, but for the purposes of treatment, 350 units a day was considered enough for a man of 60 kilogrammes weight receiving a diet of 2,000 Calories. It is widely held that the ratio of thiamin (in microgrammes) to the non-fat calories is significant as well as the actual amount of the pure vitamin available. Fisher pointed out in Nakom Paton and elsewhere along the Burma-Thailand railway the incidence of deficiencies of other components of the *B* complex was higher than beriberi, and doubted if an increased carbohydrate ration would precipitate the latter. But there are other complex factors to be considered, such as oedema due to lack of first class protein and the effect of this and other chemical and physical influences on cell metabolism. Occasional instances of beriberi were seen in the members of the force in Changi, but most of the patients came from the outside working camps. As time went on, fluctuations in the dietary scale occurred and with it deficiency diseases fluctuated also. Thus in 1944, a gross deficiency of vitamin *B* exposed the force to the risk of beriberi and when outbreaks of malaria and dysentery took place an epidemic of beriberi was produced. The T/NFC ratio in Changi dropped from 0.57 in January 1944, to 0.53, 0.43, 0.32, 0.25 and 0.23 in succeeding months, and during July was still only 0.23. Despite all effort to obtain supplements, the epidemic could not be averted, and included some cases of the cardiac type. At an early stage at Changi it was decided to classify beriberi under the following varieties: oedematous, neuritic, cardiac and those with encephalopathy. Here and in other areas certain difficulties of diagnosis were apparent. To what extent was oedema produced by thiamin defect and to what extent to protein deficiency? What objective signs should be demonstrable in the nervous system before neuritic beriberi could be recognised? What evidence of cardiac involvement was necessary before beriberi could be said to be of cardiac type? It was observed that disordered rhythm and dyspnoea were common in men with undoubted beriberi of other types, but were these sufficient proof of affection of the heart muscle? And finally, how could cerebral malaria, which might occur under the conditions prevalent in many camps, be distinguished from encephalopathy due to beriberi? Difficulties in connection with differential diagnosis of neuritic lesions have been referred to earlier, but these troubles were minor compared with those facing physicians working under conditions always difficult and often crude in the extreme. These problems will be dealt with serially.

B. NEURITIC BERIBERI

Prophecies concerning the inevitability of an outbreak of beriberi on the inadequate ration scale supplied by the Japanese were soon verified. By mid-April 1942, cases had been recognised and two sudden deaths

occurred from heart failure, believed after post-mortem examination to be due to cardiac beriberi. Experiments in yeast production were proceeding, but as yet insufficient supplements of this kind could be provided to protect the troops.

The first collected series of 50 cases contained 10 of the oedematous type, 13 of the neuritic, 2 of the cardiac and 25 combined. The predisposing factors were age, dysentery or diarrhoea, anorexia, with which the amount of food consumed was concerned. In nearly half the patients deep reflexes were lost, and in a greater number, sensation was impaired. Deep tenderness of muscles and tendons was found more reliable than surface loss of sensation for touch and pain. Oedema, when present, began in the legs in more than half, and in the face in about a quarter of the patients. Slight glossitis was sometimes seen, but no signs of other deficiencies at that time.

Though study of the clinical picture of beriberi at this early date is of some interest, it was not even then possible to distinguish symptoms of pure thiamin deficiency, if indeed such existed, from those owing in part also to protein and other deficiencies. There is indeed evidence that the Australian troops, perhaps owing to their normally larger meat ration, suffered more from beriberi than others during some of the earlier phases of their captivity. However, the coexistence of oedema with neuritic signs is recognised as a genuine part of the picture of beriberi, and there was every justification for the diagnosis to be made with confidence on this evidence. There was another good reason also. The Japanese would be more easily convinced of beriberi than some other deficiencies, owing to its prevalence at various times in their own population, and this argument, used as an incentive to obtain better rations, was more powerful than if confused by references to other deficiencies. As an official diagnosis nutritional oedema carried no conviction with the Japanese, in fact "inanition" and "malnutrition" were forbidden by them as diagnoses on death certificates.

In Changi and in the many other working camps, the symptoms of neuritic beriberi were found to be cramps, numbness, tingling, together with muscular weakness, dulling or absence of deep reflexes, an ataxic gait and paresis resulting in disordered posture, such as foot drop. An unsteady gait was often found and was due to affection of the dorsiflexors of the foot and the peroneal muscles.

In some areas, such as some of the camps endured by "F" Force, predominantly neuritic cases were rare, but a combination of oedema with hand or foot drop and anaesthesia of isolated parts like the lips, was common. There was no question that these were caused by beriberi. Although there was ample evidence of the connection between a low thiamin/non-fat calorie ratio and beriberi, a low intake of even such food as was available was in itself undesirable. It was found in some places that such a reduced intake of food ran parallel not only with poor nutrition but also with beriberi and oedema of various kinds. At Tanbaya an "eat your rice" campaign was started at a time when beriberi was increasing,

and this helped to break the vicious circle of poor appetite and lowered absorption.

Many instances could be quoted, too, of the effect of exertion. For example, in "H" Force the sustained effort of a long march under very bad conditions, after over a year of semi-starvation, precipitated an outbreak of beriberi in scores of men; during the next couple of weeks an extra issue of beans stopped the epidemic. Later, as the supplies of beans waned, beriberi again increased. These men were frequently oedematous and ankle and wrist drop appeared with dramatic suddenness. Acute and chronic cardiac beriberi also appeared. Some lives were saved by a small stock of capsules of vitamin *B*, and men urgently ill were given such dietary supplements as could be mustered from the common stock. In the working camps beriberi in some form was practically always present, and many of the men were insecurely balanced in this respect, only needing extra exertion, extra carbohydrate or an infection to produce frank beriberi.

In Japan experiences were similar, beriberi there was too often of sudden onset; neuritic or other symptoms might suddenly become manifest in men who up to that point had shown only a mild degree of gravitational oedema. In Java, in the early days of 1942, before rice polishings could be obtained, the staff of the 2/2nd Australian Casualty Clearing Station found about 90 per cent of patients had some form of deficiency disease. Some of the Dutch who were returned to the Changi area from camps both in the N.E.I. and Singapore Island suffered from advanced beriberi of all mixed forms, as well as gross oedema. For example, one very severe outbreak, including cardiac types of beriberi, was seen in a party of Dutch sent from Java to Rangoon on a grossly deficient diet. The treatment of beriberi of the neuritic type, associated as it generally was with some degree of oedema, was of course primarily a problem of supplying a reasonably adequate diet reinforced with thiamin. The prospects of doing this successfully varied greatly with local conditions and supplies. For example, the following figures taken from a special report by Bruce Hunt on "F" Force, shows the difference between the Changi area and the various camps from Konkoita to Tanbaya. The T/NFC ratio of the food at Changi was below 0.2 in March and April 1942, but rose in June to 0.345, just above safety level, and though for the next three months it was below 0.3, it rose to 0.479 in October and remained at a safe level for nearly eighteen months with the exception of two very bad months early in 1943. After this, steady deterioration took place, and for the last four months of captivity till August 1945 the ratio was not much over 0.2. It will be seen then that men with beriberi had a reasonable chance of relief in hospital in Changi. But in the Konkoita area, the T/NFC ratio was never above 0.2, and the same applied to all the camps occupied by "F" Force till after they reached Tanbaya, where the figures actually rose to 0.43 and 0.61 in October and November 1943. How could a man with beriberi be given the treatment he needed? As Hunt remarked: "The real tragedy lies in the fact that much of the disease is really curable

if proper foodstuffs and drugs are available in sufficient quantity". The figures for Tanbaya show that of a camp population of 1,500 to 1,600 during September-October 1943, the percentage of these men suffering from beriberi was from 31 per cent to 39 per cent. In August-December 1943, 413 deaths occurred from beriberi alone, and 477 others from beriberi and other coincident causes.

Where possible, severe and extensive affections of beriberi were treated by adequate nutrition; and in spite of the attempt by the Japanese to impose a still more inadequate ration on sick men, the standard attained by the hospital staffs in settled areas was reasonable, judged by the prevailing conditions. Thiamin was supplied by giving marmite,¹ two drachms by weight, up to three times a day, yielding perhaps 100 units, or by 2 ounces of rice polishings daily. Where injectable vitamin *B*₁ could be obtained up to 3 to 5 ampoules of 10 milligrammes were given daily. Paralysed limbs were splinted to prevent deformity; after a time even appliances, if needed, could be made in Changi, and re-education in movement and in walking was carried out.

In Changi, improvement in the neuritic signs was noted after two to three weeks, and cure might reasonably be expected within several months.

C. NUTRITIONAL OEDEMA

The problem of oedema is not unaptly considered in immediate relation to beriberi, for although neuritic signs and oedema were frequently seen in the same patients, they were not necessarily due to the same cause. A diagnosis of oedematous beriberi was convenient, even though it was not aetiologicaly correct. The question of cardiac involvement may be conveniently put aside for the moment.

In all areas where gross oedema was encountered, the same conclusion was reached, as it has many times and in many places before, that the chief cause was hypoproteinaemia. Even in April 1942, oedema was a striking feature in some patients in Changi, and evidence of cardiac affection in others perhaps emphasised unduly the seriousness of oedema as a symptom. But as experience grew it became apparent that general anasarca might exist without cardiac failure and without neuritic signs or symptoms. Fisher described a small outbreak among the men of an Australian medical unit at Tavoy, in which oedema chiefly of the face and the lower extremities was a prominent feature.

Later, more extensive oedema was observed in other patients who, in spite of conspicuous waterlogging, were breathless only from mechanical causes and showed satisfactory cardiac and renal function. Naturally they had oliguria, but the urine contained no albumin. Elsewhere similar states were found, and these were believed to be due to a protein deficiency in the diet; in other words, famine oedema. Treatment with vitamin *B*₁ was without effect, but feeding with a high protein diet, when this could be

¹ Where mention is made of marmite this will usually refer to local substitutes, not necessarily "Marmite" the proprietary product.

obtained, relieved numbers of patients. Naturally such a diet was difficult to provide, and it could be tolerated for only a short time by men with long standing malnutrition. Numbers of these died from intercurrent infections, some succumbing to gangrene starting in infected ulcers. Unless diuresis was started promptly by this and other measures, it was found best to cease treatment for a short time and resume after a rest. Even the successful drainage of oedema fluid from the body was not always calculated to restore the confidence of either patient or doctor, as the extreme loss of subcutaneous fat became evident when an emaciated frame appeared, a ready prey to other diseases.

Dysentery was a common prelude to these severe oedematous states. As a result of observation of the results of gastro-intestinal disease in malnourished men, preliminary starvation was discounted in the treatment of dysentery and the patients were fed within limits of their tolerance and the possible dietetic resources.

The clinical manifestations of oedema due to faults of nutrition varied from slight pitting of the ankles to the most extensive anasarca. Though gravitational influences were evident, the distribution of the fluid conformed rather to that seen in nephritis. The face was involved early, and was often swollen at the same time as the lower parts of the legs. Ascites occurred with the severe types, but the other serous membranes were seldom affected, and then in the later stages. Sometimes weakness of the limbs was observed, but this was no essential part of the picture. A coincident neuritic beriberi occasionally caused some of the usual palsies. Hunt described adductor paresis of the laryngeal muscles, usually on the right side. Oedematous parts were sometimes anaesthetic, and sometimes affected by paraesthesia; tenderness of such parts, occasionally seen in other mechanical and chemical types of oedema, was not described. Captain R. M. Mills raised the question of a nephritic element in some of these oedematous patients, such as were seen in "F" Force. He suggested the possibility of a reversible symptom complex of which one cause might be disturbance of renal function. The men in "F" Force were universally infected with malaria, and were constantly on the verge of beriberi, and other avitaminoses. Mills described a sequence in which men with slight general oedema had abdominal distress and pain, passed scanty brownish ("tea-coloured") urine, and had malaise with slight fever. The administration of quinine controlled the fever and polyuria was established, with recovery in favourable circumstances. The observation that men dying with relapsing malaria and serious malnutrition were found to have sub-acute or chronic renal changes, suggested the possibility of more common, though unrecognised, grades of nephritis. Harvey, on the contrary, pointed out that the malaria centre in Changi treated over 1,200 patients up to the end of 1943, but saw none with oedema, and that oedema in "F" Force disappeared when better diet and more adequate quantities of thiamin were obtained. It must of course be admitted that the conditions were much worse in many of the Burma-Thailand camps than on Singapore Island, but, though the possibility of impaired renal function was more

likely in the former than in the latter, it does not seem probable that nephritis was *per se* a significant cause of oedema. Again, it must be admitted that descriptions of the disturbances of renal function, recognised as occurring in some forms of malaria, are based on very different circumstances.

It may be noted without suggesting any causal relations that a very severe form of beriberi was seen in Dutch civilians who had been working very hard in a hyperendemic malarious zone; they had gross general anasarca and X-ray screening showed cardiac enlargement. Some of these severely ill oedematous patients had a raised blood pressure during the period of oliguria and intense oedema.

As an adjuvant to treatment mercurial diuretics were found to be very useful to initiate or accelerate diuresis. "Mersalyl" gave good results, but a Japanese substitute was found to be ineffective and toxic. Ascitic collections of fluid sometimes required tapping, and rarely paracentesis of the thorax.

One feature noticed in "K" Force in Thailand was the greater frequency of "oedematous beriberi" among men who had been isolated alone or in small groups in poor coolie camps. Enlargement or coalition of these groups meant more organisation, which in itself enabled supplements to the rations to be obtained more freely. In "J" Force in Japan gross oedema was not at all uncommon. It was frequently of sudden onset and of the usual pattern. Suppression of urine was a frequent feature; it was sometimes complete for 48 hours, though more usually only a few ounces would be passed in 24 hours. Free diuresis seldom appeared before about a week.

Towards the end of the period of captivity, particularly in the last six months, the number of patients with oedema in Changi gaol area increased. They had been subjected to a semi-starvation diet for some time, the ration steadily becoming worse. There can be no question that these oedematous states were due to malnutrition, chiefly lack of protein, and possibly in part also to vitamin deficiencies. It would be rash, however, to conclude that these are the only possible factors at work in the bodies of men subjected to privations so comprehensive and prolonged.

D. CARDIAC BERIBERI

In the section dealing with cardio-vascular disease the story of the late effect of attaching the diagnostic label of cardiac beriberi has been told. Different opinions were held by different medical men in Singapore, Burma and Thailand as to what could be justly called "cardiac" beriberi. Their arguments bore fruit in producing a sound and balanced outlook on the use of the term, and on the handling of men who had cardio-vascular symptoms due to malnutrition. On the one hand it was observed that men with well marked or severe neuritic beriberi, who usually had some oedema, usually also had some disorder of heart rhythm or anomaly of the heart sounds, even though no enlargement of the heart could be detected by fluoroscopic examination. At the other extreme were men

with general oedema and signs of cardiac failure with demonstrable enlargement of the heart. In a different category were men who died suddenly, and usually unexpectedly, or who had attacks of cardiac arrest. These were beyond doubt due to affection of the heart itself, but the problem was not diagnostic but rather aetiological. No great difficulty arose in recognising the beriberi heart in circumstances permitting adequate investigation, as in the Changi hospital area. Further, the steps to recovery could be traced convincingly by watching the heart decrease in size under the influence of adequate diet containing ample thiamin. The pathological parallel with the myxoedema heart can be drawn here, which serves to recall how excess fluid not only infiltrates the fibres of the heart's substance, but also embarrasses the inner metabolism of the striated muscle fibres themselves. But where no gross hydroptic state of the heart could be demonstrated, the question arose of the signs and symptoms which would justify the diagnosis of cardiac beriberi. The advantage of this label was that it gave a better chance of impressing the Japanese with the dangerously low level of the diet; the disadvantage, that it created alarm in the patient's mind, and unless he was progressively exercised readily became an invalid and acquired a cardiac neurosis. The details need not be retold here, but this was well illustrated in some of the men who returned from "F" Force, fatter than their fellows, unable, as they thought, to get about, or in some cases to get up, and unhappy in the belief that their hearts were organically spoiled. Fortunately the opportunities for full investigation restored their confidence, and encouragement to resume activity cured them. Major Bruce Hunt, in a long and careful clinical study in Thailand, compiled a list of cardio-vascular symptoms in beriberi. These comprised palpitation, with a consciousness of cardiac unrest, paroxysms of rapid heart action, irregularity, due usually to frequent extrasystoles, fatigue, shortness of breath, sighing, a feeling of oppression in the chest, sometimes amounting to pain, usually dull, and felt towards the left side below the nipple, dizziness and faintness, loss of sleep and appetite, and apprehension. Pulsations of an overacting heart were seen in the neck, chest and epigastrium. At Kanburi he carried out extensive observations, and in a series of 100 men detected signs of enlargement of the heart in 26 per cent, 20 per cent involving the left side. These observations were subject to the fallacies inherent in estimating the size of overacting hearts in thin people. Long sounds, triple rhythm, splitting of sounds and soft systolic murmurs were common. Cotter Harvey, C. R. Furner and W. A. Bye, physicians at Changi who reviewed some of these men who survived to return to Changi, and who examined many men with beriberi in Changi, often noted similar disturbances of sounds and rhythm, but did not consider that they truly had cardiac beriberi unless signs of enlargement and failure were present. Fisher arrived at similar conclusions in Nakom Paton. He reviewed a number of patients labelled as cardiac beriberi, who had been the subject of comment by a Japanese medical officer, and reported that their symptoms were due either to beriberi in the general sense, to debility from malnutrition, to other deficiencies

or to effort syndrome. This last, in other words a cardiac neurosis, was due to the impression given to many of the patients that they had diseased hearts. He undertook special training of 90 of these men and practically all were returned to work by the end of four months without any untoward effects being observed. After all, it is a matter of terminology. There is no doubt that it is better not to implicate the heart in the diagnosis except with very good reason. It must be remembered, too, that the men in the Thailand railway camps were in a lamentable state of semi-starvation and overwork; in brief, the death rate of "F" Force tells the story. It will readily be conceded that, though the diagnosis of cardiac beriberi may sometimes be technically questioned, the incidence of cardio-vascular symptoms in relation to severe beriberi was considerable. It is not surprising that apprehension was common in men who had subjective circulatory symptoms. The combination of extra-systoles and mental anxiety is well known quite apart from neuroses; indeed it would be hard to find a better example than the showers of ectopic heart beats observed in sufferers from prolonged travel sickness. It is not without interest to observe that Hunt reports that sudden deaths occurred in some men after exertion or fatigue, in particular after the discomfort of rail journeys. Auricular fibrillation was very seldom seen in beriberi in the larger settled areas, but in some of the severely ill men in the camp hospitals it occurred and was of evil omen.

Sudden deaths, already mentioned, and briefly discussed in the section on cardio-vascular diseases, were without doubt connected with malnutrition in many instances. Such happenings have been observed in the subjects of starvation. We know that a man with some stenosis of the coronary arterial system may drop dead and that no clot or other gross mechanical cause may be found *post mortem*. It seems logical to postulate a sudden dysfunction of the junctional tissues of the heart similar to the sudden interference with cardiac conduction or contraction due to nutritional disturbance. These unexpected deaths were only occasional in Changi in 1942, though one occurred within a month of the capitulation. When the depleted "F" Force returned from Thailand in 1944, there was some increase in the frequency of these emergencies, accentuated by the physical deterioration noticeable among the men. This rise in the number coincided with increased incidence of oedema and of beriberi. The peak in numbers was only six among a camp strength of 16,000, and the total number remained small. Nevertheless the nature of these accidents was very disturbing, especially as those noted in the hospital area were not associated with exertion. Attacks of ventricular arrest were also seen, resembling the Stokes-Adams syndrome. Some men recovered after repeated attacks, some after injection of adrenalin into the heart, others spontaneously. Thiamin was given to these men in repeated large doses. The clinical history did not suggest any reason other than those connected with nutritional defects. Most of the men were young and not severely ill.

In one or two instances autopsy indicated failure of the right side of the heart, but as a rule no cause was revealed. The effect of quinine was

suggested as possibly relevant, as a number of the men had been taking this drug, but there was nothing to support this. The enormous number of men, sick and well, who have taken quinine and who have had it injected intravenously without trouble, disposes of it as a possibility.

Quite apart from this small but important group of unexpected cardiac accidents, a point of some interest in cardiac beriberi was its occasional suddenness of onset. An example may be quoted of one man who had oedema of the legs and face. Orthopnoea appeared with striking speed, and X-ray examination showed that the left and right ventricles were dilated. The heart sounds showed rapid variation in their character and rhythm and there was positive clinical evidence of left ventricular failure. This man recovered rapidly on administration of vitamin B1.

Breathlessness was an important feature of cardiac beriberi; it was usually worse at night. Pulmonary oedema was sometimes observed, and occasionally periodic breathing. Although precordial pain was unusual, tightness was felt in the chest, no doubt accentuated by collections of ascitic fluid. Clinical estimation of the size of the heart was often found difficult, and was not infrequently incorrect when checked radiologically. In Changi left sided enlargement was much more common than right sided; similar findings were made by Hunt in Thailand. It is important that no conspicuous degree of dilatation was ever found in the absence of oedema, though sometimes the heart appeared of normal size even in the presence of oedema and of signs of circulatory failure.

Systolic murmurs were commonly observed and the heart sounds were often reduplicated. Gallop rhythm was sometimes observed; in a few instances the blood pressure was beyond the normal range; sometimes this was transient only and sometimes it persisted for some weeks. Fortunately the death rate of patients in fixed hospitals like Changi was low. Diuresis usually marked the beginning of recovery, and once the urinary output rose, oedema generally subsided rapidly. Where radiological examination was possible, the heart could be observed to diminish in size and generally return to normal within one or two months. The amount of cardiac enlargement due to dilatation often subsided quickly. Purified thiamin was not always available for treatment. The concentrated preparation was given when available, but many patients made a good recovery with rice polishings only. A liquid extract was generally administered, about half a pint per day; the local experts who produced this extract estimated that each pint contained over 2,000 international units of vitamin B1. In addition as generous a diet as was possible was allowed. Some of the patients admitted from the working camps on Singapore Island or other areas close to a settled hospital, although suffering from an undoubted cardiac beriberi, were not always severely ill. These men responded well as a rule to rest in bed and other appropriate treatment.

Some observations were made in Changi also on beriberi in relation to infections such as dysentery and malaria. The effect of many infections in precipitating beriberi is, of course, well known, but in some instances the onset of dysentery or recurrence of malaria induced a return of

cardiac symptoms. This did not always appear and in general, patients who recovered from cardiac beriberi, did not appear to have any residual debility, though of course in the prevailing circumstances many other dangers awaited them.

Occasional instances were seen of cardiac beriberi occurring in the subjects of organic heart disease. Naturally amongst army men there were few of these, in whom the combination of a previously established rheumatic valvular disease and cardiac beriberi was observed. It is not surprising that breathlessness and pulmonary oedema were easily produced. In other words, a lesion such as a mild mitral stenosis was a predisposing factor to failure in a heart affected by thiamin deficiency. Review of patients who had had cardiac beriberi was possible in a number of instances and it was found that the recovery of the heart was as a rule complete. In this connection the question of the significance of extra-systoles during or after beriberi was examined. Where this irregularity occurred in a patient showing other signs of active beriberi, other changes of the heart were generally also observed, but other patients, after recovery from beriberi, had persistent or occasionally recurring irregularities due to extra-systoles without any sign of organic disease. It would seem unlikely that, having regard for the general effects of malnutrition, these findings were of any particular significance in themselves. Some observations were made to see if the administration of rice polishings would effect such irregularities, but no change was observed. Reference has been made elsewhere to a report made by Major Uhr on the radiological aspects of beriberi heart. A very distinct difference was noticed in patients who came from the camp area and those who came from outside camps. This of course was due to the very bad conditions in some of the working camps which produced deficiencies of a much severer order. The latter were difficult to examine because of the great amount of oedema fluid. No films were available and screening alone could be used. The heart/lung ratio was estimated by comparing the maximum transverse diameter of the heart in moderate inspiration with the widest diameter of the thorax; a constant target-screen distance was maintained and also constant milliamperage and kilovoltage. Major Uhr found as the result of three years' observations that the "normal" heart there was smaller than usual. The average heart/lung ratio was 1:2.5. In a number of patients it was possible to demonstrate a substantial enlargement, usually of the left ventricle, which was restored to average size by successful treatment. Twenty-three out of 35 cases showed enlargement of the left side. Oedema of the lungs was not always demonstrable and fluid in the pleural cavity was uncommon. A feature commonly seen in the acute condition was broadening of the mediastinal shadow.

E. ENCEPHALOPATHY

Occasional instances were seen of cerebral seizures conforming to the descriptions accepted as characteristic of encephalopathy due to dietetic deficiency. Some of these occurred during the first few months after the

capitulation. This is consistent with the epidemiology of cerebral beriberi, which is known to occur rather in the first stages of exposure to thiamin deficiency. Cases of encephalopathy have been reported in British soldiers in Changi, and post-mortem examination showed haemorrhagic lesions in the mid brain such as described by Wernicke. In another fatal case reported from Malaya the lesions were in the *pons*, but the cause was not clearly established. The diagnosis of thiamin encephalopathy may be confused by the coexistence of deficiency of riboflavin and nicotinic acid or by cerebral malaria, though the post-mortem findings in the latter should be easily proved. The later onset of other deficiencies in communities on an insufficient diet makes encephalopathy of earlier occurrence much more likely to be due to thiamin. This early appearance of cerebral forms of thiamin defect applied not only to Singapore but to Java also. Here Major R. H. Stevens reported cases of sudden illness in which patients complained of headaches, became stuporose and had convulsions. Lumbar puncture showed the fluid to be clear, but under pressure. The cause was believed to be cerebral oedema due to deficiency. In various places affections of the cranial nerves were occasionally seen, particularly diplopia, but it was not easy to decide whether these manifestations were due to deficiency of thiamin or of another vitamin, such as riboflavin. For example, a man with neuritic beriberi showed signs of laryngeal and palatal palsy, had diplopia and incontinence of urine with high fever. The diagnosis made was cerebral beriberi, but intercurrent infection of the nervous system was possible. Similarly, affective changes, vomiting, and ocular muscle palsies may be seen in patients with neuritic beriberi, but it does not follow that they are necessarily due to insufficient thiamin. A. C. P. Campbell and W. Ritchie Russell have pointed out that oculomotor disturbances are the most common cranial nerve sign in thiamin encephalopathy, but that diplopia and paralysis of conjugate movements may be due to combined deficiency of thiamin and nicotinic acid. Similarly ataxia and other signs of lesions of the lateral and posterior columns may occur also in beriberi but it does not follow that the cause is single. However there seems little doubt that there was a relation between the early encephalopathic states seen in Singapore and elsewhere and the known lack of thiamin in the diet.

F. SCROTAL DERMATITIS

One of the earliest deficiency states to appear in Changi was scrotal dermatitis. As usual, a few instances were seen in the beginning, heralding an epidemic outbreak beginning in July. Paralleled by the appearance of lesions of the mouth and tongue and by painful burning feet, this condition attained its highest incidence in August. Many medical officers have described it, a typical description is that of Major B. L. W. Clarke. He recognised four stages: (i) erythema with vesiculation, invariable symmetrical in distribution, (ii) cracking with weeping, (iii) extension to the penile and other neighbouring skin surfaces, and (iv) oedema and patches of ulceration, with intertrigo, and spread to the anus. Patients requiring admission to hospital needed 6 to 8 weeks for reasonable

recovery, and the lesions readily broke down if hard work was resumed too soon. Radical changes of diet had been imposed on the men, who were only having 15 ounces of rice a day and a few ounces of meat a week. In some areas the incidence was later, as for instance, in a force which arrived in Thanbyuzayat in October 1942. A few men had red scaly or raw weeping scrotal skin, a little later a few had painful feet and failing sight. The numbers rapidly increased to hundreds, and in June 1943 there were 400.

In Changi, aggravation of the lesion was often seen following the application of irritating dressings. Once again the old lesson had to be learnt about an inflamed skin; red palm oil with a trace of zinc oxide was usually found suitable. Gunther, who observed large numbers of men there, found in about 100 men a uniform bright pink appearance of the scrotal skin which was non-rugose, smooth and shiny, thickened and inelastic. Many of these men had stomatitis or glossitis, and preputial lesions were seen too, sometimes with considerable swelling. The most effective treatment was marmite, which cured or improved all on whom it was used; 86 per cent improved on yeast within a week, and 67 per cent on rice polishings, but after two weeks only 47 per cent who had yeast were cured and 29 per cent of those taking rice polishings, whereas by that time 82 per cent were cured by marmite.

Clarke tried fruit juices, yeast, vitamin *B*₁, vegetables and peanuts, without much benefit, and found marmite, and to a lesser extent vegemite, effective, though more than two drachms caused diarrhoea. Rice polishings had little effect, but these were often dirty and impure. The arrival of Red Cross stores made a distinct improvement. Half doses of ultra-violet light gave some relief. Gunther analysed a series statistically at Selarang, and his results confirmed the findings that success in treatment was quicker and more uniform with marmite than with other supplements.

This was a most uncomfortable disorder, made worse by the climate. Itching was persistent, worse at night and exaggerated by friction. Chemical irritation caused chiefly by anti-tineal preparations caused added inflammation. In Clarke's series, 75 per cent of the men with scrotal dermatitis had glossitis, 50 per cent palatal erythema and 25 per cent burning feet. Some also had cracks behind the ears and sticky conjunctivitis, and small but increasing percentages had granular cornea. The symmetry of the scrotal lesions was a constant feature, but the raphe was uninvolved. In advanced cases, pain was considerable, and spread to the cords which were swollen and tender. Now and then diphtheria occurred as a complication. Usually it could be recognised by its yellow membrane, with the added symptoms of pain and toxæmia.

In Changi, after April 1943, a few severe cases of scrotal dermatitis were seen, partly owing to the shift of the population from the area, but partly also to the increase of supplements to the diet provided through the endeavours and insistence of the force itself.

In numbers of working camps this lesion gave similar trouble and in general its appearance and severity were paralleled by the presence or

absence of an adequate amount of vitamin *B* complex in the diet. In Kami Sonkurai from August to November 1943, "F" Force, though under bad conditions, was relatively free from painful feet and scrotal dermatitis. This was probably due to the regular consumption of "jungle stew", compounded of leaves of wild pumpkin and other plants, also eaten as spinach.

In Changi, too, towards the end of 1942, the addition of rice polishings and the improvement of the general diet were apparently responsible for the virtual disappearance of scrotal dermatitis. In the later periods, during 1944, after serious falling off in the ration scale for some two months, an epidemic broke out again of a composite kind in which scrotal lesions were prominent. At this time, scrotal dermatitis which had previously been seen as a predominant, though by no means a single, lesion, appeared with a variety of other deficiencies due to lack of riboflavin and niacin. This was the experience in the worst working camps too, where multiple deficiencies begot multiple diseases. Thus, in Thailand, Hunt records seeing all the lesions of eyes, skin and mucous membranes that could occur. The resultant disability was often not severe, but as Hunt correctly reported at the time "much more trouble may be anticipated from this source unless the diet of the troops is substantially enriched in the near future by substances containing the *B*2 complex (riboflavin and nicotinic acid)". Most of "K" Force was also effected by scrotal dermatitis, glossitis and stomatitis in 1943, but it is interesting that the severe forms of these diseased states such as occurred in Changi in 1942, were not seen.

In "J" Force after a year in Kobe, Japan, a review by Captain Boyce showed that scrotal dermatitis was the commonest deficiency symptom with the single exception of the disorders of vision. In this force over 60 per cent of the complaints causing men to seek medical relief were due to dietary deficiency.

G. LESIONS OF THE LIPS, MOUTH AND TONGUE

Bracketing the lesions affecting the lips, mouth and tongue is merely a convenience in clinical description, for it does not imply that all these were due to the same cause.

Cheilosis and Angular Stomatitis

The lips were sometimes red and swollen, they might become dry and fissured, and weeping or scabbing might be present. Extension of fissuring and inflammatory changes occurred later, and might even involve the skin on the face up to half an inch from the muco-cutaneous junction. The angle of the mouth was frequently involved, fissures formed and invasion of skin was likely to occur at this point. In severe affections, possibly aggravated by some low-grade infection, a fungating mass might form on the red portion of the lip.

Buccal Lesions

The mucosa of the cheeks and palate was sometimes in discrete lesions. These might be white thickened plaques, seen chiefly along the line of

occlusion of the teeth, and not infrequently blebs filled with sanious fluid formed on the cheeks and palate. Occasionally the lesions would spread to the anterior faucial pillars and in later stages ulceration occurred.

Erythema of the Palate and Pharynx

Palatal erythema was distinctive enough to be recognised as an entity, and sometimes spread to the pharynx. The tissues became swollen and tender and sensitive to heat, and swallowing became painful. Associated glandular swelling in the neck was also seen.

Glossitis

This term is only used loosely, for all the changes seen in the tongue were not truly inflammatory. Lesions of the tongue appeared later than those of the mouth, but it did not always follow that a complaint of soreness of the mouth was due to lesions of the mouth, as investigation sometimes showed that it was really the tongue which was sore. A glazed red atrophic tongue was a variety frequently seen, but this was not an early stage. The first abnormal appearance was leucoplakia, after which the tongue became swollen. The papillae were involved in this change and became enlarged. The next stage was fissuring, though in some series no fissuring was seen. Fissures were sometimes wide, and ran more longitudinally than transversely, but also extended to the edges. These changes sometimes ran in cycles: return of the papillae would initiate healing, but relapse would then occur reproducing the glazed painful condition of the tongue.

Hypopharyngitis

Inflammatory changes sometimes extended as far as the lower part of the pharyngeal mucosa, and even to the vestibule of the larynx. Rarely the arytenoids were involved and even oedema of the glottis occurred. This condition was a later sequel of the lesions described above. It gave rise to great discomfort and pain and was sometimes complicated by a superadded streptococcal infection with enlargement of the cervical glands. Toxic symptoms were associated with this condition. Such severe manifestations were relatively common towards the end of the first wave of deficiency states in the later part of 1942.

More will be said later of the place of these tissue changes in the general picture of deficiency disease, but they can be conveniently regarded as readily recognisable manifestations of lack of certain elements of the B complex, apart from thiamin. These appear to be riboflavin and nicotinic acid.

H. PAINFUL FEET

The syndrome known as painful feet or burning feet has been described from many places where there has been dietary deficiency. It is sufficiently distinctive from its clinical aspects to stand as an entity although it appears to have been sometimes a stage in the development of other deficiency states. This condition appeared early in the prison camps. In Changi it was common amongst members of the A.I.F. during June and July 1942 and

reached its peak from August till October 1942. It recurred in 1944, following another period of bad diet, but on this occasion the symptoms were less severe. It caused great disability, particularly during its first visitation. An epidemic which occurred in Manchuria among prisoners of war was also severe and here it would appear that the extremely severe winter accentuated the symptoms. The age of the patient seemed also to bear some relation in the severity. In 100 men carefully investigated by Captain M. Woodruff, who was acting as medical research officer for the A.I.F., about three-fifths of the men were fit for duty, one-quarter for light duty only and the remainder were unfit for any work. The most troublesome symptom was a pain usually described as burning in the feet, mainly in the metatarsal area, extending to the toes and also to the ankles, heels and soles, and sometimes to the calves. A curious finding was observed in two men who had both had one leg amputated some months before for wounds received in action. Both of them complained of feeling pain in both feet. The pain was dull rather than sharp, but there was, particularly in 1942, a persistent burning quality in it which was very hard to tolerate and as the symptoms were usually worse at night, loss of sleep was common.

Affected men bathed their feet or rubbed them to get relief and commonly walked about owing to the difficulty of remaining still, particularly at night. Some suffered from "starts" or spasmodic jerking of the legs during periods of rest; some tried immersion in cold water to gain relief and some of the men in camps in Manchuria even exposed their feet to the bitter cold or put them in snow, a practice which naturally was forbidden.

The hands were often similarly affected, but to a lesser extent. The general condition of the men was the same as that of the other prisoners, but loss of appetite was noticed to be common among them; so too was mental depression. This may have been due to the constancy of the complaint and to loss of sleep, but it is possible that it had some further significance. A large percentage of the men, rising to some 80 per cent, gave a history of some other form of deficiency attributed to lack of *B2* complex. Thirty per cent of the men with painful feet at Changi had stomatitis and in some other areas the percentage was greater. Oedema and neuritic signs in the legs were unusual in those suffering from painful feet, only about 8 per cent in 1942.

During a review of the men in this area, the sequence noted was beriberi, affections of certain of the exposed areas of the skin and mucous membranes, and painful feet. It was shortly after this that deficiency states which affected the eyes began to appear.

Examination showed the feet and legs to be reddened, but although the patients experienced the sensation of heat, the skin was not necessarily hot and more usually felt cold to the touch. Superficial tenderness was common; arterial pulsation was good and although clearly seen, was not abnormal. Sweating was common; the skin often felt clammy and nutritional changes occurred in the nails, which became ridged and brittle.

None of the men complained of deep pain or muscle tenderness. A considerable proportion of men had exaggerated knee and ankle jerks.

Clonus and other signs of disturbances of the pyramidal tracts were sometimes seen in patients who afterwards showed progressive symptoms of spinal cord affection. Twenty-three per cent of one series had increased deep reflexes, but ankle clonus was found in only a few of these. The appearance of this sign did not necessarily indicate that further nervous changes were pending. A small percentage had sluggish reflexes which of course were of no special significance. In some instances there was evidence of impaired circulation in the feet, particularly in their slow reaction to temperature changes. The condition bore a resemblance to that described under the name of erythromelalgia. The cause of this condition was undoubtedly a dietetic deficiency, and some of the evidence supported the belief that it was due to a vascular affection due to insufficiency of part of the vitamin *B* complex, probably riboflavin.

The sequence of this clinical state with reference to other clearly differentiated conditions was constant in the areas in which it appeared. For instance at a combined meeting of Dutch and Australian medical officers at Bandoeng in October 1942, it was noted that *tinea cruris* had been prevalent; then scrotal dermatitis appeared which failed to respond to local treatment. At the same time lesions of the mouth and tongue were observed pointing to the existence of vitamin deficiency. Yeast or extra food improved these conditions, but within a month men began to complain of burning feet, and soon this reached epidemic proportion, 10 per cent of the camp strength being attacked. Shortly, ocular troubles appeared in about one-fifth of the men with painful feet. This is only one of many similar experiences and it appears to incriminate lack of part of the vitamin *B* complex, probably that including riboflavin and nicotinic acid.

In Changi it has been pointed out how the occurrence of these disabilities followed the very poor diet of the early period. The same thing happened again in 1944, when the soya bean and other supplements used in the diet were not available and maize was substituted. This was possibly objectionable in itself, if some of the hypotheses concerning pellagra are believed, but the diet was also deficient in calories, thiamin, riboflavin and nicotinic acid. Then it was that painful feet returned in another though less severe epidemic. It is interesting to note that both here and in a number of the working camps where the burning feet syndrome was again encountered, its return was by no means so severe. The same was observed about relapses. No correlation existed between the symptoms of this state and consumption of tobacco, and in general there was no evidence of any toxic cause. There seemed to be some racial influence, as the Ambonese and Manadonese in camps in Netherlands East Indies had few avitaminoses and hardly any trouble with their feet or eyes in spite of the insufficiency of the diet.

The Australians were severely attacked in 1942. One suggestion advanced to account for this was that they were usually heavier in their average weight and were accustomed to a high protein diet owing to the

liberal allowance of meat in their standard ration. It is possible that protein metabolism may also have played some part. Another point which may be important is that manifestations believed to be due to pellagra appeared later on but were not seen at the same time as painful feet. Treatment also sheds some light on the nature of the condition. It was naturally most effective in men whose symptoms had not been long established.

In an investigation carried out in 1942 in Changi, results were apparently obtained from nicamide, thiamin, rice polishings and yeast, but dosage was very restricted on account of the small quantity available. Injections of calcium were tried, but had no effect. Later, when grass extracts were produced in considerable quantity, and particularly when soya bean was available, the conditions seemed to subside. As a general routine in hospital, the use of rice polishings, marmite and extracts of towgay, providing riboflavin, seemed to be satisfactory. Extra food designed to improve the balance of the diet was effective if available, particularly when yeast was also given.

Early in 1943 in Burma at Thanbyuzayat, a troublesome outbreak occurred; the only supplements available were bananas and eggs, but these appeared to give satisfactory results. Treatment by vitamin *B1* extract was unsuccessful. In camps in Netherlands East Indies it was found that one egg and one drachm of yeast daily would cure lesions of the lips and mouth and scrotal dermatitis, but would not affect painful feet. Doubling this supplement, however, was successful. It was suggested, therefore, that there might be a combination of lack of calories and first class protein with a lack of the *B2* complex. Further experience with nicotinic acid was not encouraging. Infra-red radiation was tried at Changi with an extemporised apparatus; it seemed to give some relief of symptoms, but no controlled observations were made. An important factor in treatment was the wearing of properly fitting boots, provided these were available, and foot exercises were beneficial. Sedatives were sometimes necessary.

An observation of some importance was made by Coates in Burma. He was successful in relieving the symptoms of a patient with severe pain in the feet by dividing the superficial peroneal and tibial nerves. At the operation a distinct swelling of the nerves was noticed, but no microscopic examination was possible. He supports the view that the vascular changes were at least associated with an abnormal state of the peripheral nervous system. This fits in with the observation that neurological disturbances such as spastic paraplegia may occur as direct sequels of burning painful feet.

Captain D. J. Brennan, in his observations of severely affected men in Manchuria, pointed out that the feet looked very different at night; in the daytime their colour was a dull slaty grey and the skin looked thick and smooth and was dry, but at night the feet were swollen and, while there was no pitting on pressure, the bright red skin looked tense and shiny. The veins were dilated and stood out prominently as far as the knee or

even further. Some degree of spasm was present in the muscles of the leg. At night also hypersensitivity of the skin was more evident to touch and pain, but the perception of heat and cold was not altered. The arteries could not be palpated at night owing to intense pain. He also observed that ankle jerks were sometimes difficult to elicit on account of the muscle spasm. No hypertension was found. Some of these findings are significant from the point of view of involvement of the nervous system. Brennan thought that the vasomotor changes were secondary to a disturbance of the autonomic nervous system and also felt that cold produced aggravation of the symptoms.

It is interesting, too, that these severely affected men were Allied soldiers who had been under bad dietetic conditions for some time before coming to the camp at Mukden. Patients with a long history, as some of these had, could not be relieved easily, and in any case no real facilities for treatment were available in Manchuria. It seems possible that structural damage occurred in some of these men, who had symptoms still present even after three years. This contrasts sharply with the experience in Changi where, with the better conditions and facilities, the outlook was very good, as all the patients improved under care and recovered ultimately without any residual symptoms.

I. SPASTIC PARAPLEGIA

During the months in which the men in Changi experienced their worst epidemic of the burning feet syndrome, a small group of cases of spastic weakness of the lower limbs was seen. It has been shown that increased reflexes were not infrequently observed in the subjects of painful feet, even occasionally with ankle clonus and extensor plantar reflex.

Consideration of the times at which the different clinical syndromes appeared suggests too the possibility of a relation between this malady of the nervous system and lesions of the skin and mucous membrane. Between June and October 1942 some 40 patients with spastic paraplegia were seen in the Changi area; only 6 of these were Australians. The mildest cases occurred at the end of the period, and after this the disease disappeared and was not seen again. W. A. Bye reviewed 18 patients in Changi hospital. There was no evidence that these men had suffered any severer degree of malnutrition than others, or that a greater proportion of them had had dysentery or diarrhoea. The death of three patients from dysentery is probably irrelevant.

The onset was usually sudden. Within several days weakness of the legs appeared and became severe. Movements were noticeably clumsy. Both legs were usually affected, though not always equally, and the arms were often involved to a lesser extent. Occasionally the trunk muscles were involved also, and the patient was left temporarily almost helpless.

The first symptoms were subjective, but objective signs, though at first misleadingly absent or inconspicuous, soon appeared. Sometimes a slower onset made the diagnosis of organic disease difficult in the early stages. All degrees of paresis were found, but there was no wasting. All the usual

signs of pyramidal tract involvement appeared; flexor spasm was common. Sphincters were involved only in the severely affected patients, who died. Sensory changes could not be demonstrated other than those usually found in association with beriberi. A high temperature was found in men severely affected, a sign also observed in occasional cases of other nervous disease believed to be due to vitamin deficiency. In such men the mental state was seriously disturbed; this was not usual, though some impairment of memory and concentration was noted in a few. Loss of visual acuity was found in the severe cases; it was difficult to test the visual fields of these men, but no fundal changes or scotomata were apparent. It was possible that any changes in the visual neural paths were in the optic tracts, radiation or cortex.

Dysarthria was a well marked symptom in some. Facial weakness was seen in a very few. No skin lesions or other conditions suggesting pellagra were observed. Lumbar puncture and examination of the blood did not reveal any abnormality.

These patients were treated on the assumption of a deficiency state, with dietary supplements. Though some of them could be given special food only during their acute state and thereafter had the average diet of the camp for that period only, they made satisfactory recoveries, without relapse or recurrence.

Some degree of recovery began as a rule within five or six weeks and after four or five months in hospital, or less in less severe affections, the patients were usually well. Even though function was satisfactorily restored, some exaggeration of the reflexes often remained. Some disability often remained in the form of stiffness or weakness, but not sufficient to prevent carrying out of light duty. Even two years afterwards, a patient capable of doing light work has been found to have hyperactive deep reflexes and ankle clonus.

In general, power in the arms was recovered, speech if previously affected was normal, and some changes persisted in the lower limbs. Nothing suggestive of a pellagrous state was found in these men at a later date; they had no lesions of the skin or mouth, no chronic diarrhoea and no mental changes. In a few, permanent disability remained, not severe enough to prevent standing or walking, but enough to hinder complete freedom.

The cause of this syndrome was believed to be deficiency of protein and of the vitamin *B* complex in the diet. It is hard to see why its incidence was so limited and why no more cases occurred. The existence of some degree of disturbance of pyramidal tract function in the painful feet syndrome suggests a sequential relation, but on the other hand there are undoubted affinities with some of the experimental and other lesions attributed to pellagra. We must of course admit the logical danger of assuming that the use of the name of a disease such as "pellagra" explains its cause or describes its pathology. It may be remarked that numbers of men who died in the working camps of the Burma-Thailand railway were diagnosed as having pellagra by experienced medical officers. If this

paralytic disease was a form of pellagra, it might have been expected to appear among these men. Post-mortem information is meagre about this form of spastic paraplegia, as examination was limited to macroscopic scrutiny. Lesions were observed in the white matter of the brain, especially in the posterior and superior part of the cerebral hemispheres, extending back into the occipital poles. There were circumscribed, symmetrical rounded areas of a grey translucent appearance. They were thought to be due to demyelination. It was fortunate that the changes in the nervous system were not irreversible in a greater number.

J. LESIONS OF THE SKIN

The most obvious and destructive of all lesions beginning in the skin was the "tropical ulcer". This is described fully in other sections. It is mentioned here because it is beyond question that these lesions would not have attained the size and extent they did in the Japanese prison camps had the nutrition of the men been adequate. There is no doubt that dietary deficiencies played a considerable part in undermining resistance to infection and in hindering normal healing. That there was often a deficiency of vitamin *C* in the diet is beyond question. Captain W. Aitken noticed petechiae particularly in the skin of the arms of men on Hainan Island whose diet was deficient in vitamin *C*. Scurvy as a clinical syndrome was not recorded, but experience in the world during the 1939-1945 period has abundantly shown that clinical syndromes, due to deficiency states, even appearing in epidemic forms, frequently did not conform to the patterns regarded as classical. Probably in the worst working camps, such as some of those in Burma and Thailand, almost every possible permutation and combination of dietary deficiencies existed at one time or another, together with infections against which few measures could be taken. It may well be that a lack of vitamin *C* and of elements of the vitamin *B* complex, whose metabolic influence is exerted in part on vascular tissue, was an important factor in perpetuating ulcers. Apart from the septic ulcers, the most serious lesion of the skin was a generalised dermatitis. This has been mentioned in the section on dermatology, where its occurrence is described under conditions of satisfactory nutrition. In the present instance the additional factor of nutrition is undoubtedly important, but this does not preclude the possibility of toxic or allergic causes also operating. Whether a hypothetical toxin is of intrinsic origin or not, its potentiality for harm may easily be greater in the presence of disturbed cellular metabolism. Scrotal dermatitis has been regarded as a local specific manifestation of exfoliative dermatitis, and the connection of this lesion with avitaminosis is reasonably certain. The peculiar susceptibility of the skin and mucous membranes in persons lacking important vitamins of the *B* complex is well known. Therefore, without our being committed to a diagnosis of pellagra, meaning by this the end states described under that name, it is admissible to refer to "pellagroid" conditions of the skin.

Such rashes, when affecting exposed areas of skin, were symmetrical and photosensitive, and were common in certain areas and at certain

periods. They were first seen in Changi in 1942. In men seriously malnourished in the worst camps, this type of rash was sometimes associated with loss of muscular power and some mental deterioration. Chronic diarrhoea was very common owing to the prevalence of bacillary and amoebic dysentery; it would be impossible to ascribe it to pellagra or to any single cause in many of the men so affected. Post-mortem examination on men who had had such manifestations often showed the whole intestine to be thin and translucent with a smooth atrophic appearance of the mucosa. Coates and other surgeons commented on this state of the bowel as seen in abdominal operations. Further reference will be made to this later.

The pellagroid rashes resembled sunburn in the early stages, and were delimited at the edges, though not always with absolute sharpness. Pigmentation and desquamation were soon observed. It is curious that the back of the neck was not always affected, though this area was usually unprotected. Pigmentary anomalies were also observed on exposed parts, apart from this photosensitive dermatitis. Areas of deepened pigment formed by aggregation, leaving others depigmented.

Associated with these skin lesions were usually the familiar conditions of the muco-cutaneous junctions and the affections of the lips, mouth and tongue already described. These are, in part at least, ascribed to a defect of riboflavin, but are often clinically recognised as part of the pellagrous syndrome. Consequently, some medical officers referred in their reports to pellagra, where others merely described the appearances seen or related them to a deficiency of the *B2* complex in general. Among groups of men with rashes aggravated by the sun, scrotal dermatitis, oedema of the feet, stomatitis, cheilitis and glossitis were also frequently observed, and occasionally too, some degree of nerve deafness.

In 1945, when the state of nutrition in Changi was deteriorating rapidly, parallel with a steadily worsening dietary, pellagrous dermatitis increased greatly in amount. After working in the sun, men would have painful inflammation of the skin over the outer arms, the backs of the forearms and hands, the backs of the knees and the dorsa of the feet. Occasionally the face suffered also, but the neck, shoulders, back and chest were less often affected. At this time, lesions of the mouth were not usual, one of those curious exceptions to the experiences elsewhere at other times, that sheds some light on the condition. It was noted too that ascites was then occurring more frequently, probably owing to shortage of protein in the diet; tapping was more often necessary to relieve the symptoms.

One feature of the diet which is of probable importance then is that maize was included in the diet from the 20th March 1945 to the 21st May 1945, and then withdrawn. Sun rashes became more common at the latter part of this period, and a little later when many such rashes were being seen, maize was re-issued. The connection between maize and pellagra has been the subject of much argument for years. Reference will be made later to the possible effect of black beans in the diet; these

matters are of interest, as suggesting the plausibility of the hypothesis that one effect of certain vitamins may be detoxication.

Special interest was given to the observation of lesions of the skin in Changi when a new symptom-complex appeared in the area. The word "new" is used in the sense that these manifestations had not previously appeared as an entity there. The clinical features of the syndrome were inflammatory lesions of lips, mouth and tongue, dermatitis, and changes in the blood. The most striking feature of the blood disturbance was neutropenia, which will be described separately later. These new manifestations caused the skin lesions to be described with special care, and the following details taken from a report by Lieut-Colonel W. A. Bye, set out the skin conditions observed in this outbreak.

The lesions varied in severity from mild erythema to generalised exfoliative dermatitis. Only the exposed parts of the body were affected, and these areas were symmetrical. The earliest signs were either pin-point papules, or small vesicles on the shoulders or abdominal wall, with a red swollen base. Rupture of the vesicles left a raw weeping surface. Less often scarlatiniform, or even purpuric rashes, were seen. Itching or burning or tingling was complained of, and sometimes the onset from this early stage was very rapid.

Desquamation was usual, and occasionally was extensive in amount and degree, and between the peeling areas there might be eczematized patches. In over 25 men, severe exfoliation was seen; large pieces of skin were sometimes shed, cracks and fissures often being left. Exfoliation sometimes recurred repeatedly on the affected areas, which in the interim were pigmented, though soft and tender. After 3 or 4 months leucodermic patches appeared in a number of men, either small or large, on the exposed parts or between the fingers. Fever was common during the period of exfoliation. Bye noted in a few men an appearance on the palms resembling an early stage of pink disease. Though similar photosensitive rashes had been seen in Changi in 1942 with clear demarcation of the affected areas, this feature was now lacking.

Discussion of the aetiology of this condition is better left until the blood changes have been described.

K. CHANGES IN THE BLOOD

Although there was no doubt that many men suffered from anaemia, full investigation was usually impossible. There is no record, for instance, of any series of anaemia of macrocytic type as might perhaps be expected, but the existence of this and of other types of blood disturbances cannot be excluded.

One variety of important change in the blood and in the bone marrow was investigated in Changi in March to May 1944 when what was known as the "new" syndrome appeared. One of the features of this was a form of myelophthisis in which the white blood cells were involved. The appearance of some of the lesions of mucous membranes of the mouth and throat suggested the possibility of a neutropenia, and blood counts, both total

and differential, were then carried out by Major Maynard, A.A.M.C., on all patients whose condition was serious. Three men died and in each instance the total white cell count was reduced, and particularly that of the neutrophile cells. Counts in these fatal cases were sometimes as low as 2 per cent neutrophile cells, the lymphocytes rising to 80 or 90 per cent. In a few instances bone marrow was obtained by sternal puncture. Observation of other patients who recovered showed that a severe neutropenia sometimes occurred, but was usually transitory, and after an interval varying from one to three weeks, total and differential white cell counts became normal. As is usually the case in neutropenic states, the white cell count in itself did not give a true indication of the prognosis. It may be noted, however, that in no instance was a total absence of granular cells observed. The lower white cell counts were associated with the more severe lesions in the mouth and throat, but even severer exfoliation of the skin did not produce any substantial lesion of the blood. Anaemia of itself was not a feature of these conditions, though of course it was seen in connection with relapsing malaria and other infections. There was no evidence that these blood changes were due to drugs. Sulphapyridine was used in the treatment of intercurrent dysentery and sometimes for lesions in the throat itself. Total doses did not exceed 5 to 15 grammes and observations of the blood counts did not suggest any connection between the two. Recent experimental work sharpens our interest in these syndromes, as skin pigmentation has been described in deficiency states, and nutritional leucopenia has been successfully treated with folic acid.

Post-mortem examination in the fatal cases showed findings consistent with deficiency disease of a pellagroid type and of severe neutropenia, with its usual septic sequels. The possible causal factors of this syndrome were carefully considered in a report on the subject, which pointed out that during the previous two years the diet supplied to the men was of a very low Asiatic type. It was curious that during the earlier periods symptoms of the skin and mucous membranes such as are often associated with pellagra, were frequently observed. It was realised that in accordance with the more recent views in the literature, such signs were possibly due to deficiency in riboflavin, but all that could be said definitely was that the signs and symptoms were possibly due to a lack of this and other components of the vitamin *B* complex. In February and March 1944 the rice ration was reduced in amount and for the first time maize was added to the diet. The average issues per man per day varied from about 2 ounces to 4 to 5 ounces. Whether there was any association between the maize and the onset of pellagroid symptoms cannot be stated. Major Burgess, R.A.M.C., who was an expert on nutrition, prepared analytical tables of the diet supplied to the troops throughout the whole period in Changi. These tables showed that in April and May 1944 a slight fall in the caloric value occurred, but even more significant was a substantial fall in the amount of nicotinic acid in the diet. This began in January 1944, and in May remained unaltered. The riboflavin content of the

diet fell also progressively through the year, though there was no sudden drop such as took place in the nicotinic acid. Dietary supplements at this period were also very scarce, rice polishings were unavailable, towgay had not been issued for some time and fresh vegetables and fruit and eggs were very scarce. In February 1944, black beans were added to the ration in average daily quantities of 1.5 to 2.3 ounces per man. Both in Changi and Kranji, it was thought that some relapse or exacerbation of skin conditions occurred each time these beans were added to the diet. Some men appeared to be upset by them, but no definite evidence of any toxic effect was forthcoming. Skin tests were made with an extract of the bean, without result. It was thought more prudent to omit them from the diet, though without definite proof of the necessity. The question was also raised of the possible importance of coincident infections of the throat, but throat swabbings did not support this suggestion. It seemed rather as if a defect of blood formation or maturation preceded the onset of secondary infections. It was therefore concluded that this was a true deficiency disease. Men affected were treated with marmite, limited amounts of rice polishings, or extract of towgay and soya bean. A very limited supply of nicamide was held, but very little could be spared for treatment. In the limited experience possible, results did not seem to be encouraging. Grass extract was used in doses of a pint daily for patients who could tolerate it. The grass used was blue couch or *paspalum* or lalang, extracted by boiling and concentrated. Pain on eating and swallowing was considerable in many instances and frequent feedings of soft diet were given.

It is of interest to trace the further developments of this deficiency state. After May 1944 the numbers fell rapidly. Lesions of the lips and mouth became less severe, no ulceration was seen, exfoliation of the skin did not recur and no neutropenia was found. This improved state of affairs was observed not only in the hospital area, but also in the various units. At this time many patients were transferred from Changi to Kranji and the same improvement occurred there also. It was noticed, however, that men who had recovered from exfoliative dermatitis had certain sequels. They lost considerable weight, were very easily fatigued and had chronic skin changes. Non-pigmented patches could be seen on the skin of the face, chest, shoulders and back and limbs. These were very subject to sunburn. Between the pale patches, the skin was browner than usual, and a number of men showed also a chronic purplish pigmentation on the backs of the hands. As these men could not tolerate exposure to the sun, they were regarded as suffering from a chronic mild form of pellagra.

At this time also an increase in manifestations previously attributed to vitamin *B2* deficiency began to recur in the area. A certain number of men complained of abdominal discomfort and mild diarrhoea, but it was by no means sure that this was due to deficiency. No neurological abnormalities were observed. It seems warrantable to conclude that by August 1944 pellagra with its associated lesions of *B2* deficiency was endemic in the Singapore camps.

L. EYE DISTURBANCES

(a) *Corneal Degeneration*

Early in June 1942, a number of men began to complain of what appeared to be a form of superficial keratitis. This was also described as "granular cornea", for keratitis was not a completely accurate description. The symptoms were sometimes slight; conjunctivitis and blepharitis were occasionally seen, but little or no discomfort was usually felt. There was sometimes a slight feeling of grittiness, with some sensitivity to light and occasionally lachrymation with a little discharge. Affection of vision was usually slight. Faint opacities and irregularities were seen on the cornea with slight injection around it, and a drop of fluorescein produced fine corneal staining. This staining was diffuse, but had a punctate appearance, discernible with a *loupe* and good illumination, and was usually more evident over the lower and more exposed part of the conjunctiva. Sometimes a line of fine spots could be seen crossing the centre with minute branches. In more advanced conditions, the punctate areas coalesced, causing loss of epithelium over a wide area. The lesions were superficial and Bowman's membrane was seldom involved. The corneal reflex was usually present, and there was little interference with sensation. The progressive changes in the corneal epithelium can be summarised as steaminess of the cornea, granulation and superficial ulceration.

In August and September 1942 it was noticed that the men in hospital who were having marmite for the treatment of skin conditions showed improvement of these corneal lesions. Marmite in this respect was more potent than vegemite. Rice polishings seemed to produce little result. These observations and consideration of the prevalent conditions pointed to the existence of another deficiency disease.

During November and December, the incidence fell, owing probably to the availability of some dietary supplements, some of which came from Red Cross food. These supplies ceased in December, and in March 1943, there was again an increase in corneal degeneration. It may be also relevant that in January 1943, prophylactic rice polishings could not be obtained. This lesion, as Major Claffy pointed out, was not inflammatory in nature, though the changes in the cornea differed from those described in the literature as a result of lack of riboflavin. He suggested that the cause might have been a combined deficiency of vitamins *A* and *B2*. In support of this, it was noted that the incidence fell after palm oil was added to the diet, which was rich in vitamin *A*. Varying degrees of night blindness were occasionally seen among the prisoners of war, but this was not a feature at this time, and the other lesions described such as softening of the cornea and Bitot's spots were not seen. The evidence of an *A* deficiency was presumptive only.

Local treatment had very little effect and usually consisted in the use of oily drops. The condition seemed to have a natural tendency towards recovery. One of the most valuable local methods of treatment was to keep the eye covered; if this was done, the cornea soon became smooth

and fluorescein staining disappeared; but if prematurely uncovered, the eye tended to relapse. Response was obtained as a rule within two to ten weeks, but sometimes recovery was further delayed.

In the latter half of 1942, it was noticed that the degree of visual impairment apparent in these men was greater than could be accounted for by the corneal lesion. Further, while the granular state of the cornea as a rule resolved with little or no residual scarring, the eyesight did not always improve.

Major R. G. Orr found that even severer corneal lesions cleared well without any permanent defect when extract of lalang grass was given, but from the evidence it is hard to determine the effect of separate dietetic supplements. After the first epidemic outbreak, corneal degeneration as a single deficiency symptom gave relatively little trouble, but was seen from time to time to some extent under conditions of inadequate nutrition. Even when troops were returned from the prison camps to Australia a certain number of men had a loss of lustre in the epithelium of the cornea and a few spots due to superficial nebulae. This deficiency syndrome, like most of the others, kept up some smouldering activity. As the number of men with ocular complaints increased, it became evident that a more serious type of affection of the eye was becoming prevalent. This form of deficiency disease, known variously as retrobulbar neuritis and deficiency amblyopia, continued to be of importance throughout the whole period, although the numbers waxed and waned gradually from time to time.

(b) Deficiency Amblyopia

The name retrobulbar neuritis has also been used for this, but as it does not resemble the usual forms of this complaint and has a different pathology, it is perhaps better to use a more non-committal term.

In the Changi areas, the numbers showing interference with vision, increased rapidly at the end of the year, the peak occurring in January 1943. It is possible that a growing consciousness of the significance of any dimness of vision caused a large number of men to report early, especially as the importance of early treatment was stressed.

Affected men noticed blurring of vision; this might be in one or both eyes, but always began in one first and involved the other later, an important point in the matter of early treatment. The blurring affected particularly near vision so far as subjective sensations were concerned. In reading, for example, words would drop out, and if the affected area was central or near-central, the functional loss was all the greater. Occasionally a kaleidoscopic type of image was seen owing to the movements of the eye in an effort to fix a central vision.

Both Major Claffy and Major Orr saw large numbers of men with this eye condition, collected details of their findings with great care, and kept records of the results of treatment. There was some difference of opinion at first among those carrying out treatment as to which dietary supplements were most successful and whether it was essential to admit all patients

to hospital for early thorough treatment. A difficulty arose in treating all patients as in-patients on account of the shortage of hospital beds.

Much was, and still is, obscure about this disease, but though differences of opinion were held on certain aspects, general agreement was reached about its most important features. Major Claffy issued a number of reports on the subject, and collected his experiences into a report covering the whole period of 1942-1945. Major Orr and Captain Woodruff, in the Selarang area, examined the various factors which might be considered the bases of treatment, and tried to ascertain on statistical grounds which were the most effective methods to pursue.

In the hospitals in Changi and Kranji, 2,000 patients with this disability were seen of Australian, British, American and Dutch nationalities. Soon after the appearance of corneal degeneration, detailed examination of the eyes of some patients showed the presence of scotomata.

By October 1942, amblyopia reached epidemic proportions, which were maintained until July 1943. At one time, out of a total of 830 patients in hospital, 500 were being treated for amblyopia. After this the incidence decreased, owing partly to better diet and partly to the moving of some of the force from Changi. Part of the Changi Hospital was moved to Kranji in May 1944, where conditions were more primitive. Here, after a latent period, relapses occurred and fresh cases appeared, but the produce of a communal garden of some 28 acres and the addition of the right kind of greens and of soya bean induced remissions. About this time the total calories of the diet provided by the Japanese were reduced and although bodily resistance declined as a result, the diet was better balanced and for a time no fresh cases occurred. Later again, new cases once more appeared and among the patients was a certain proportion of men who had partial ophthalmoplegia. Occasional instances of this condition had already been reported by medical officers in other areas, but very few had occurred until this group appeared. These pareses were believed to be due to thiamin deficiency. Patients with this form of amblyopia showed varying degrees of impairment of vision. If this was 6/18 or less, searching movements in the eye could be noted in an attempt to obtain fixation. The pupils usually reacted normally and examination of the fundus of the eye rarely showed change. Occasionally slight blurring of the discs, indicating a mild papillitis, was recorded. In this series 1.5 per cent had retinal haemorrhages, usually small, but occasionally of moderate size, although there was no evidence of fragility of the other blood vessels. Bitemporal pallor has been sometimes described, too, but this is a sign to which importance cannot always be attached. There is no doubt that severe loss of sight could occur with no substantial change in the eye grounds. Since the return of these prisoners of war, it has been again demonstrated by the observance of controls that pale discs and the presence of deep cupping may exist without any interference of vision. On the other hand, large scotomata may exist without any such retinal findings. Nystagmus was only rarely seen. The one characteristic lesion was the scotoma. Within the limits of its area, loss of vision was para-

central or central or caecocentral or annular. The scotoma was for white and sometimes for colours; for example, for red in the early stages, but this was not characteristic. A pathologist noted this in himself when he could not distinguish the red stained tubercle bacilli on a microscopic slide.

Peripheral vision was usually not affected, but sometimes some contraction could be observed. For practical purposes, it appears to be true that complete blindness has not occurred. Accompanying symptoms were slight only. Loss of clarity of vision was sometimes accompanied by a feeling of strain, and photophobia was an occasional complaint. Work in a strong light seemed to produce a sensation of aching behind the eyes in some men. Vision was better in dull light, especially in the evening. The loss of visual acuity might be confined to one eye or might affect both.

Aetiology. Apart from general causes, such as lowered nutrition from insufficient or unbalanced rations, intercurrent disease and excessive muscular work, other factors considered were a specific vitamin or other dietary defect or an endogenous toxin, which might be produced by the resultant disturbed metabolism. There appeared to be a specific damaging effect on the neural elements of the retina or on the axis cylinders of the nerve bundles. In any case, the lesion was a peripheral one, and the absence of half or quarter field defects indicated that the part affected was below the chiasma. Experiences in treatment has shown that some of the milder types of amblyopia would become stabilised without specific treatment. This was probably due to a restoration of the vitamin requirements through lessened strain on the general metabolism, or possibly to some degree of bio-synthesis. Such spontaneous recovery of course could take place only when the changes in the nervous structures were not irreversible. Other forms of avitaminosis were observed in patients with amblyopia, but these varied in the different periods and shed a little light on aetiology. In December 1942, for example, 75 per cent to 80 per cent of the men with painful feet, stomatitis or scrotal dermatitis, also had amblyopia, but a year later the percentages were only from 2 to 15.

Amblyopia was common also in the poorly fed men of the worst working camps, but here co-existence of other deficiency states was much less common than in Changi in 1942. Major Moon in the 2/2nd Australian Casualty Clearing Station in Java, divided the men into several groups, each receiving one special variety of food in addition to the usual ration. The supplements included liver, eggs, meat, beans and fruit. He found that no new cases of affected sight occurred in the groups receiving extra animal protein; in this regard tinned meat appeared of definite value in prevention. A large amount of carbohydrate had a bad influence and appeared to accelerate the appearance of amblyopia.

In a discussion on this subject by a group of Allied medical officers held in August 1942, after the epidemic had begun, the following features were noticed. Australians (usually heavy meat eaters) were affected early, burning feet preceded the outbreak of amblyopia, no pellagroid signs were noted at the time; other races contracted pellagra without having ambly-

opia, and no connection was found between the existence of lesions of the skin and of the eye.

The results of treatment gave some information on the aetiology. Major Claffy reported good results in a series of one thousand cases, with of course the proviso the treatment was not so effective once the lesions were firmly established. He considered that rice polishings alone had no value and that marmite, together with as satisfactory a diet as could be contrived, gave good results. Major Orr and Captain Woodruff analysed another series treated in the Selarang area. No evidence could be found to implicate tobacco of any other known potentially toxic substance, and experiments on the possible effect of replacing various items deficient in the diet were not quite conclusive owing to the limited numbers, but it appeared from this that thiamin and nicotinic acid alone were ineffective, although the amounts of the pure substances available were very small. The results with marmite, rice polishings and yeast, together were better than with those of marmite alone. The varied degrees of affection of the different men and the slow rate of recovery in some, made assessment of results difficult. Supplies of marmite were difficult to maintain; but when this was unavailable, the use of soya beans in the form of "tempe" and other garden produce such as kang kong and spinach was encouraging. Soya bean and kang kong appeared to be the most effective substances. Long term experience over the three years of captivity showed that all patients treated early did well and most of these had very little, if any, permanent impairment of vision. Where atrophic changes had occurred, even without demonstrable pallor of the retina, the conditions usually remained almost stationary. Unfortunately, it was possible to treat men from some of the working camps only when their condition was already far advanced; an example of such was a series admitted from Pulau Dama. A certain degree of improvement took place up to 18 months or 2 years, but after that nothing more could be expected. There was evidence in favour of the view that avoidance of heavy muscular exertion and of an unbalanced ration containing too much rice, were measures of great importance in the treatment of this condition. Some degree of optimism was justified even in severe progressive cases as the atrophic changes might stop at any stage. In fact, it was believed that treatment produced some degree of improvement in practically every instance. Analysis of 844 cases after an average of 2 months' treatment, showed that over 90 per cent of the men had 6/18 vision or better in each eye, and 50 per cent had 6/9 or better in each eye. It was thought that 7.5 per cent were left with a marked residual impairment of vision. The degree of permanent disability depended not only on the extent of the damage, but on the position of the scotomata.

In some of the long continued cases, there appeared to be a chronic bilateral form of this disease. In this, peripheral vision was usually intact and it was thought that a loss of central vision was due to involvement of the papillo-macular bundle. Recurrences and relapses occurred in

numbers of men; these were believed to be due to unfavourable changes in diet or undue exertion.

Major A. R. Hazelton had opportunities in base areas in Thailand for studying men with nutritional amblyopia who had been subjected to excessive fatigue as well as partial starvation. When these men came under treatment at Nakom Paton in 1944 hospital dietary supplements were more readily obtained, and some Red Cross supplies were available. Leucomata following corneal ulceration were common, and active corneal lesions were frequent. Photophobia was often observed, particularly in men suffering from nutritional amblyopia. As sufficient dark spectacles could not be obtained, the total number available was ingeniously increased by cutting lenses in half and fitting them in extemporised frames made from tin cans. Hazelton's clinic also used extemporised apparatus for

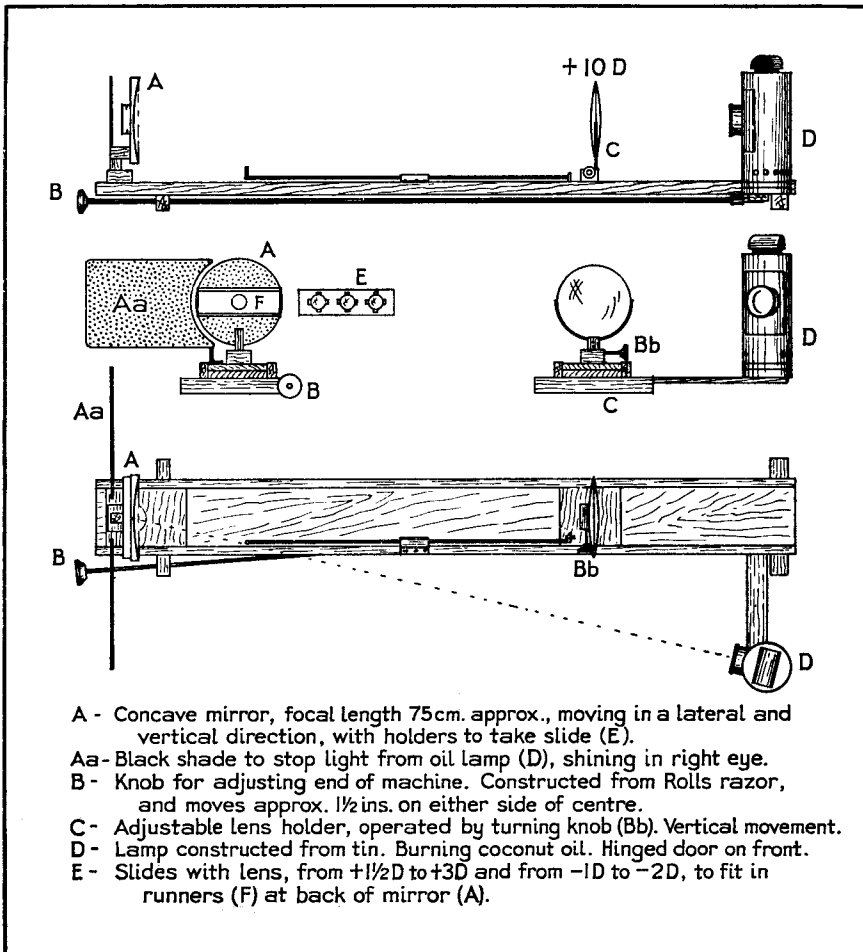


Diagram of ophthalmoscope constructed in Nakom Paton by Major A. R. Hazelton.

testing and assessing visual function in the amblyopic patients. Promising results were obtained in cases of short duration by the use of a special diet containing 10 eggs per day for 30 days. Tests of visual acuity, fusion, and fields of colour vision showed distinct improvement in all cases in this series, and one patient was considered cured.

In summing up the results of treatment, it would seem fair to say that no true specific was really in the hands of the medical officers. The removal of a man from conditions of laborious work, and unbalanced or improper diet in which a number of substances were deficient, such as protein, calcium, phosphorus, vitamin *A* and the various components of vitamin *B*, even without special treatment, probably allowed him in many instances to swing the balance towards recovery.

(c) *Night Blindness*

Experience in men in the field showed that night blindness could not be accepted as an organic disability unless demonstrable by tests. In certain circumstances it is not surprising that protective symptoms of a functional nature arose, but these were not of common occurrence. When undoubted malnutrition and a deficiency of vitamin *A* were present, night blindness was occasionally recognised. Amongst soldiers of the 8th Division, it is impossible to state how common it was, but decreased visual acuity at night was observed in some in association with and following attacks of conjunctivitis. Soreness and watering of the eyes, usually with little purulent discharge, were features of these attacks. As the diet improved these symptoms and the lowering of visual acuity by night also improved.

Examination of the diets in the prison camps shows that lack of vitamin *A* was very common, the daily figure seldom reaching 1,200 international units. In Nakom Paton in March 1944, the total vitamin *A* available was under 1,100 international units; in January 1945 it was 1,888 international units, but on August 1st-10th, when the end of the war was imminent, it rose to 8,470 international units, a striking increase after the previous figures, which were always below standard requirements. Special diets for the sick provided more, through the efforts of hospital staffs, so that a man with acute dysentery, for example, would receive 6,000 international units vitamin *A*, dropping back to 1,560 in convalescence. The higher figures were obtained from locally grown kang kong, which contained 100,000 international units per 100 grammes. In the Nakom Paton area, night blindness was apparently very uncommon and xerophthalmia was not seen.

Further special reference to this subject will be made in the volume describing medical work in the Royal Australian Air Force, which like all air forces, was particularly interested in the visual capacity of air crews.

OTHER FORMS OF DEFICIENCY STATES

Isolated symptoms of various kinds appeared among malnourished prisoners of war which are hard to place because their cause was obscure.

Nocturnal diuresis was one of these, and occurred frequently. Due apparently to an effect of poor nutrition on renal function, it was a manifestation of a partial failure of the kidney to concentrate salt constituents. It may have had a vasomotor basis, and has been attributed variously to lack of riboflavin, vitamin *A* and protein, but its cause was unknown.

Other single symptoms arising in malnourished persons are probably better considered as part of the total effect of deprivation on the body.

Sprue is worth a passing notice. *Sprue* of the "tropical" variety was seen from time to time among troops on tropical service. The usual features were noticed, and full investigations were carried out in base hospitals in Australia on a few soldiers and airmen found to be suffering from the disease. One soldier had served two years in the Middle East and six months in New Guinea. Others had served for varying periods in the islands. Within a short period three soldiers were admitted to an A.M.F. hospital in Queensland, but this was probably coincidental, as cases occurred sporadically only in small numbers. A member of the nursing services was found to have *sprue* while in Colombo. The response was a favourable one, such as is usually characteristic of *sprue* of the "tropical" type, and intestinal and haematological disorders resolved under dietetic and replacement therapy.

Starvation

Finally it is well to draw attention to the importance of adequacy and balance of the major nutritive elements of a diet. When considering the extraordinary epidemic waves of distinct clinical syndromes which swept over the more unfortunate communities of prisoners of war, it is necessary to realise that they were not suffering from a single deficiency. At any given time a particular symptom pattern was prominent or predominant, but as such patterns appeared and disappeared the steady effects of general malnutrition were slowing and distorting the working of the metabolic machine. Many of the changes produced were persistent, some were irreversible, some made the weakened bodies more vulnerable to disease, and often to fatal disease. In a given physical state seen in grossly undernourished persons, who can say which changes are due to deficiencies of specific foodstuffs, or specific vitamins, or their imbalance, or which are due to sheer starvation? Here we cannot enter into the physiology of starvation, but must remember the importance of absorption of a sufficiency of food. Attention has been drawn to the conspicuous thinning of the walls of the alimentary tract, observed both in the living and the dead. This and other signs of abnormal response of tissues to trauma of all kinds are evidenced in the destructive "tropical" ulcers, beyond all civil experience. Difficulties in absorption were obvious in some of the emaciated patients liberated in time to have their lives saved, and the greatest care in selection of diets and in feeding was necessary to avoid undue strain on a fragile mechanism.

It was recognised in some of the prison camps that men were suffering from starvation, a deprivation of sufficient food to sustain life. Sudden

death was seen in beriberi; it was also seen in starvation. In Changi post-mortem examination revealed in these cases an atrophy of the heart, liver and spleen, and thinning to transparency of the intestines. Similar changes have been described in European prison camps where specific avitaminoses such as beriberi were not observed.

Finally it is most difficult to distinguish between disturbed mental states due to the environmental conditions, against which only the firmest of spirit could have prevailed, or those due to specific deficiencies, or to starvation or to all three.

One of the features of vitamin C deficiency has been described as mental depression and apathy. This was thought by medical officers to exist in some camps where ascorbic acid in the diet was insufficient for requirements. Without any special stress on this suggestion, it may be remarked that combatant officers were impressed by this state, in which there was vacuity of spirit rather than absence of mind, and an absorption in abstraction and misery. Lieut-Colonel H. R. Humphries, in charge of "H" Force in Thailand, concluded an interim report on the camp conditions as follows:

"A frightening and peculiar symptom was manifest at one period, an intense, fixed but vacant kind of stare being present in the eyes of every man, and its despair could sometimes be detected in the countenances of some. I am certain in my own mind that in most cases this was purely physical, and a direct result of the low standard of diet."

CONCLUSIONS

The most striking features of malnutrition in Australian experience during the war have been the clear-cut serial clinical syndromes which occurred during long periods of inadequate nutrition in Japanese prison camps. Study of the literature shows that accurate descriptions of many of these states had been written a number of years before the war. Perhaps in the general medical world it was not realised that such conditions could arise again on so large a scale in a trained and well-equipped force. The tragic experiences of the 8th Division have shown what magnitude problems of malnutrition may assume, but have also indicated some possible adjustments which the human body may make. It is significant that while certain clinical pictures disappeared and did not appear again or appeared with lessened force, others persisted or appeared when comparable conditions arose. A certain relationship may be established between dietetic deficiencies and clinical phenomena, but there are so many variables that this cannot be pressed too far. The variables are such as troop movements, the amount and nature of work done, intercurrent disease, total caloric value of diets, balance or imbalance of the constituents of diets, and lastly the idiosyncracies of race and of individual. The diets available for most of these men were subject to serious deficiencies, particularly those of protein, calcium, and the vitamins *B*, *A* and *C*. The vitamin *B* complex and such components as riboflavin and nicotinic acid were probably more important than thiamin. The example of oedema quoted in the text shows the importance of multiple causes. For purposes of diagnosis and treat-

ment it was convenient to subdivide clinical states into categories. These were not really rigid, and overlapping was common. Thus it was possible to lay down certain criteria for the diagnosis of "cardiac beriberi" but it cannot be denied that the heart was implicated in the severer forms of beriberi.

Nutrition is in the post-war years one of the most, perhaps the most important single problem facing the world; the earnest studies of medical men faced with the frustrate task of dealing with grave nutritional disorders under conditions of stringent restriction help to lay emphasis on that problem.

APPENDIX 1

Japanese ration scale for British and Allied troops 1942.

Rice	500 grammes (17.6 oz.)		
Salt	10 "	(0.352 oz.)	
Meat	50 "	(1.76 oz.)	
Milk	15 "	(0.52 oz.)	
Oil	10 "	(0.352 oz.)	Yielding 463 grammes Carbohydrate
Tea	5 "	(0.176 oz.)	66 " Protein
Flour	50 "	(1.76 oz.)	20 " Fat
Vegetables	100 "	(3.52 oz.)	2296 " Calories
Sugar	30 "	(1.05 oz.)	

Australian Standard Army Ration

Preserved meat	12 ozs.		
or Fresh Meat	16 ozs.		
Bread	16 ozs.		
Potatoes	12 ozs.		
Fresh Vegetables	12 ozs.		
Sugar	2 ozs.		
Bacon	2 ozs.	Yielding 488 grammes Carbohydrates	
Cheese	2 ozs.	175-185 " Protein	
Butter	2 ozs.	166-170 " Fat	
Jam	2 ozs.	4224 " Calories	
Condensed Milk	2 ozs.		
Salt	$\frac{1}{2}$ oz.		
Tea	$\frac{1}{2}$ oz.		
Coffee	$\frac{1}{3}$ oz.		

(On Jan. 1940 8 ozs. of orange or pineapple juice were added.)

APPENDIX 2

From an article by Cotter Harvey M.J.A. 1/6/46.

Year	CH grams	P grams	F grams	Calories	T/NFC	Riboflavin milligrams	Nicotinic Acid milligrams
1942							
Mar.	481	49	21	2,120	0.196	0.77	6.0
Oct.	536	86	51	3,030	0.48	2.1	21.3
1943							
Feb.	490	43	47	2,430	0.39	1.3	7.4
Aug.	548	86	49	3,054	0.53	2.6	17.5
1944							
Average	480	55	50	2,600	0.28	1.9	7.2
1945							
Mar.							
Workers	203	32	45	1,746	0.32	0.76	3.8
Non- workers	244	27	44	1,486	0.38	0.70	3.1
July							
Workers	261	26	52	1,623	0.36	0.68	3.2
Non- workers	227	25	51	1,482	0.39	0.65	2.8

APPENDIX 3

Analysis of dietary supplements (Captain E. K. Cruickshank, R.A.M.C.)

	C gm. %	P gm. %	F gm. %	Vit. B1 mgms. per 100 gm.	Riboflavin mgms. per 100 gm.	Nicotinic Acid mgms. per 100 gm.
Rice polishings	41	23	17	2500	0.25-0.5	20-40
Soya Bean	27	36	16	300	0.09	1.2
Green Grass						
(Phaseolus)	64	21	—	300-400	1.32	0.8
Ground Nut	22	20	48	800	0.94	5.9
*Green Leaf						
Veg.	3	2	tr.	50	0.50	0.40
Millet (Ragi)	72	12	2	200-300	0.30	0.8
Marmite	—	33	1	700	3-10	100

Nicamide (1.7 c.cm. ampoule) = 295 mg. Nicotinic acid.

Crystalline B1 = 1 mg. 333 I.U. (1000 microgrammes)

Requirements B1 — 1000 microgrammes daily.

R.F. — 2 mgm. daily.

Nicotinic acid — 20 mgm. daily.

* The extract used cannot be assayed: its Riboflavin content will depend on soil, fertiliser and method of extraction.

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