## CHAPTER 29

# ENVIRONMENTAL CONDITIONS

### *HEAT*

THE importance of the study of the effect of heat on men under training first became evident in Palestine in 1940. Previous efforts had been made to educate all training units in the correct procedure designed to prevent the pathological manifestations of extreme heat. Technical Instruction No. 11 of the Middle East series embodies the principles adopted in the A.I.F. in the Middle East, and is representative also of the views and practice of all services. (See appendix.)

Of the varieties mentioned in this, the least important was found to be the classical heat stroke or heat hyperpyrexia. Heat prostration on the other hand was by no means uncommon and was important, as the supply of water and of salt was involved.

Some of the combatant units of the I Australian Corps in training, started with the idea of attempting to accustom the men to a reduced water ration. The fallacy of this was pointed out and the danger of assuming that thirst, which is a physiological warning, could be disciplined past a certain point. The A.D.M.S. of the 6th Australian Division in the Western Desert advised against cutting down the water ration, although of course care was taken that the men did not consume unduly large amounts of water owing to the risk of loss of salt. In some instances salt was added in the correct proportion to supplies taken on manoeuvres or men were given either water or tea containing a quarter teaspoonful to the pint. In numbers of instances where on "khamsin" days, when hot wind was added to the discomfort of great sun heat, some men suffered from heat exhaustion. This occurred, for example, when a number of recently arrived men who had been taken to a staging camp where arrangements for food and water were not good. In June 1940 also, heat exhaustion and dehydration were seen in many men on brigade exercises owing to an insufficient allowance of water. Muscular cramp was occasionally seen and readily relieved by salt.

It is likely that some of the effects of water and salt depletion were not always recognised at the time. Fatigue and weakness, headache, apathy and dizziness, symptoms all produced by this cause, might be readily thought to be due to other causes. It is significant too that attacks of renal colic sometimes occurred in men newly arrived in the tropics, especially when exposed to exertion in severe heat. Sometimes a few red blood cells were found in the urine, but no other abnormalities, and if the symptoms were sufficient to cause vomiting, further dehydration took place, thus emphasising the renal symptoms. It has been mentioned elsewhere that the appearance of red cells in the urine in soldiers in the

Middle East was sometimes associated with oxaluria, but dehydration was a possible factor, which might easily have been overlooked.

When the campaign area shifted to the Pacific Islands, very different conditions were encountered in which the heat was frequently associated with a very high and constant humidity. This was further complicated by problems of clothing. In the Middle East the bitter cold of the desert nights in Cyrenaica, and the mountains of Greece and Syria demanded heavy clothing, but in the heat of summer, the comfort of shorts and shirts was usually permissible. In the island areas where malaria was hyperendemic, it was necessary that the body should be covered even though unpleasant side effects occurred. Not only was greater discomfort felt from the humid heat, but exhaustion occurred more easily, and troublesome skin reactions became much more common. These are described in the section on dermatology. The observations of Molnar and others are relevant here. They found in the Californian Desert that clothing reduced heat gain at air temperatures over 90°F., but not between 80° and 90°F. In general loss of heat by evaporation kept the body temperature constant despite heat gain from the environment.

In the Pacific Islands the need for salt became more urgent and salt tablets became a regular issue. Members of forward surgical teams in New Guinea, working under conditions of intense heat and humidity, found that they needed salt as much as combatant soldiers. G. Newman Morris remarked that in a surgical team: "A good batman is worth his weight in gold: he will see that smokes, tea and salt are ready". Many men in the Japanese prison camps were acutely aware of salt deprivation, accentuated by conditions of work and climate.

The actual figures relating to human requirements of salt are impressive, and useful data was published in 1943 by the War Office. In a brochure on salt, requirements in hot climates were given as 2 grammes per hour for a man at work and 0.5 when at rest; 12 grammes per day for sedentary occupations and 24 grammes for hard work. In a temperature of 95°F. and humidity 80-85 per cent 5.6 litres of sweat may be lost per day, and under conditions of great heat (100°-120°F.) and low humidity (25-30 per cent), as in a desert in the tropics, 4 to 8 litres. It would not be easy to supply the theoretically needed 1.5 to 2 gallons of water a day.

In febrile illnesses dehydration became an important factor in the tropical climates. This was more obvious where loss of blood had occurred, but it was equally important in conditions like severe malignant malaria, toxic dysentery and scrub typhus. It should be noted too that typhus is often associated with a fall in the chloride concentration of the blood.

Special precautions were taken in hospitals in tropical areas and fluid balance charts were found to be of the greatest importance in ensuring that dehydration was prevented, particularly in patients who were unable to cooperate well in the matter of taking fluids. The lack of initiative in drinking fluid commonly seen in sick, dehydrated patients was in part a sign of toxaemia and probably in part also a symptom of loss of salt. Orderlies, who were usually responsible for routine administration of

fluids, were taught to regard this as one of the most important of their duties, particularly in diseases like dysentery, which caused considerable fluid loss. Loss of salt may of course be proved by a simple test of the urine.

In parts of the Australian continent the heat disturbances were also seen not infrequently. For example, in a prisoners' working camp in Western Australia muscular pains and cramps were observed, owing to salt deficiency under conditions of great heat. In Queensland, at a physical training school, the A.D.M.S. of the 4th Australian Division carried out some observations on temperature of men undergoing training. He found that in hot weather with humidity at or above 74 per cent, the average rectal temperature in a group of men at rest was 100.4°F., whereas in temperate climates it was almost one degree less. Fifteen minutes vigorous exercise produced a rise of 1.8°F. in men fully clothed, but only 1.2°F. in men wearing only shorts.

Though severe instances of insolation or heat stroke were hardly ever seen, the observation was repeated that men suffering from the effects of heat showed exhaustion and were observed to sweat less, even to the vanishing point. In Mesopotamia in the 1914-1918 war K. G. Hearne found temporary suspension of sweating a reliable danger sign of impending heat stroke.

The waging of war in a hot climate produced some changes in the resuscitation of patients suffering from wounds involving much loss of blood. It was soon found, in the desert, that caution was necessary in applying heat to such men owing to the danger of increasing dehydration. It should be noted, however, that, as C. E. Corlette pointed out, a light covering such as a blanket tends to slow down heat loss, and that although heat is not easily transferred from the air to the body, this is possible if the skin temperature is low, say under about 90°F.

Great variation existed in the environmental conditions in operating theatres, not only in forward areas but also in base areas where the facilities for adequate ventilation were primitive. The provision of an air-conditioned ward in Lae for example was found very helpful to some severely ill men.

During the war, Professor D. H. K. Lee of Queensland pursued research on the reaction of man to tropical climates. One set of experiments was carried out on effective work in conditions of humid heat artificially produced. The salt-water balance was less strained than in conditions of dry heat. An attempt was made to come to some conclusions on acclimatisation, and it was found that in subjects living in Queensland there was a lower salt excretion, which indicated that acclimatisation had probably taken place already to some extent. O'Brien's work, outlined later, pointed to similar conclusions.

In the Royal Australian Navy, environmental conditions were, as in other navies, of great importance. Sometimes long periods were experienced in tropical climates with the ships under action conditions. In these circumstances internal ventilation was often very poor and the conditions below

decks extremely trying. One advantage was the possibility of discarding all heavy clothing. On the other hand, repeated changes of climate were often experienced, making it difficult to attain any degree of acclimatisation.

The medical officer of H.M.A.S. *Yarra* described the trying conditions near Basra, where the ship was stationed in mid river for long periods with a shade temperature usually 105°-110°F. and never below 100°F. Fortunately hospitals on shore were reasonably cool.

Similar conditions were experienced in numbers of other tropical areas. On H.M.A.S. *Lachlan* sweat rashes were much more common between decks; salt tablets—15 grammes twice a day—were administered to the engine room staff before they went on watch.

Surgeon-Commander J. M. Flattery described heat exhaustion on H.M.A.S. *Australia*. The closing down of the ship at night imposed considerable hardship owing to the lack of natural ventilation. The average temperature of the engine room was 117°F. and in certain parts the maximum was 125°F. No instances of heat stroke were seen, but heat exhaustion and gastro-intestinal disturbances and muscular cramps were all encountered. On occasion, the diagnosis between abdominal heat disturbances and other abdominal disease was not easy, but the response to salt was dramatic. Gastric types of the disturbance with epigastric discomfort, vomiting, headache, restlessness and irritability were found; there was occasionally an associated diarrhoea. The routine was adopted of giving each officer and man a half-teaspoonful of salt in water twice daily, using the tablets if possible. During the next two months only one instance of heat exhaustion was observed in a stoker who thought the salt might make him sick and had not taken it.

Flattery also points out that educational methods of preventing salt deprivation states are the most effective. Thus to ensure the routine taking of salt, a ration is better than adding salt to the drinking water.

Surgeon Lieut-Commander M. J. L. Stening also studied in detail the problems of salt deficiency in tropical climates; his study was based on two and a half years spent mainly in the equatorial zones. The subject of environment is of particular importance to a navy. It is further expanded in the Royal Australian Navy Medical History.

### TROPICAL ANHIDROTIC ASTHENIA

J. P. O'Brien carried out an extended study on the general and specific effects of the condition called by him and Allen "tropical anhidrotic asthenia". Reference is made elsewhere to the work of Allen in the Northern Territory when he noted the occurrence of headache, exhaustion and shortness of breath in some men while working in heat. Most of the men concerned had suffered previously from prickly heat. The dry skin and gooseflesh type of rash were noticed to be characteristic sequels of exertion. Thirty-two other cases of this condition were described in detail by O'Brien, and many other instances occurred. In 1944 O'Brien prepared a memorandum on the subject for the D.G.M.S. of the Army for distribution among medical officers. The patients studied were seen in

parts of New Guinea, Morotai and Borneo. Numbers of observers have described various aspects of exhaustion states arising in the tropics, and contributions have been made to the literature in particular by American writers.

The symptoms of this state usually followed an attack of "prickly heat" or *miliaria rubra*. On the average, the subjects of the enquiry had been 6½ months in the tropics before they began to suffer from prickly heat. As a rule itching of the skin had improved or subsided by the time general symptoms arose, hence the skin manifestations were not a prominent feature of the patient's history, though important aberrations of the function of sweating were readily observed as will be seen.

The average course is as follows. The onset is insidious, the patient notices that exercise, particularly in the sun, causes throbbing headache, dizziness, shortness of breath, palpitation and later transient dimness of sight. Fainting does not occur unless the warning signs are not heeded and exposure to heat and exertion continues. The breathing increases in depth as well as in rate, up to 50 per minute, and the temperature averages about 100°F. The blood pressure does not appear to be much altered, though some response to exertion has been observed. Eosinophilia is common. Polyuria has been described, but this does not seem to be characteristic, and depends on fluid intake. Usually any readjustment has been made before the patient is seen. The urine is alkaline as a rule, and in the patient at rest there is some evidence of alkalosis. Dehydration and thirst do not occur. The face and forehead sweat profusely, the palms and the soles also sweat, and sometimes the axilla and the groin. Otherwise the trunk and limbs are dry and the skin feels hot, thick and dry. The covered parts of the skin are free of sweat, and numerous deep, dull white vesicles appear, but these do not surround the hairs as in true gooseflesh.

The diagnosis of this condition has led to some difficulty, as heat stroke, heat exhaustion and anhidrotic asthenia have to be separated. Heat cramps are of course distinctive. O'Brien points out that heat exhaustion is regarded by Ladell and others as largely due to dehydration, and that the profuse sweating which can be produced in the subjects of heat stroke is characteristic. He found, too, that moderate degrees of the characteristic changes in the skin occurred in numbers of troops ranging from 30 to 70 per cent, the high figures coming from the more active units. It was noticed that occasionally the anhidrotic state was mistaken for a psychiatric condition.

The explanation of this condition is not altogether clear. O'Brien suggests that the disturbance of circulation is due to dilatation of peripheral vessels. Though there is no reddening of the skin, biopsies reveal congestion in microscopic sections. He suggests, too, the possibility of reabsorption of sweat from the vesicles with some toxic action. The over-breathing might represent a panting response, but there is no evidence of this, though there seems no doubt that alkalosis is due to the respiratory disturbance. Tetany can occur in heat exhaustion, but it has not been

observed in this series, although it has been described in men observed in Iraq. A review of the literature shows considerable agreement between workers in different places. Rise in temperatures and lack of sweating have commonly been found, though a relationship of the latter to miliaria has not always been established. A sandy texture of the skin has been described.

O'Brien found that the condition lasted 4 to 12 weeks before normal sweating was restored, but one attack did not necessarily confer immunity. There was a tendency in some men for miliaria to recur in waves in which groups of sweat glands were affected in turn: in severe attacks the majority of the glands might be involved. Sometimes improvement did not take place, and the symptoms of the syndrome progressed. This may possibly be linked with the genesis of some of the more persistent and troublesome dermatoses in the tropics. For further descriptions of the changes in the skin and their possible relationship to other conditions the section on dermatology should be consulted.

Ladell, Waterlow and Hudson, in their observations in Iraq on water and salt balance, laid emphasis on the low urinary output both of water and salt in spite of high intake of water. They described a "type II" of heat exhaustion which is certainly identical with Allen and O'Brien's anhidrotic asthenia, and noted that these occurred in the latter part of the hot weather when prickly heat was in the healing stage. The question they have raised, whether severe miliaria is usually or inevitably followed by general symptoms, is answered by O'Brien in the affirmative.

Discussion of the causes of sweat failure and of its possible relation to fatigue of sweat glands leads to considerations of alterations in the water and sodium chloride balance and of aberrations or reactions in the central nervous system. It is evident that more research could be carried out with profit on this subject. *Miliaria rubra,* long thought to be merely a nuisance of hot climates, seems to be bound up with wider problems such as that of acclimatisation. Certainly it is suggestive to look at the sequence of prickly heat occurring some months after arrival in the tropics, followed in some persons at a shorter interval by asthenia, then circulatory and respiratory distress after exercise associated with anhidrosis of the covered areas of the skin.

## *COLD*

Exposure to cold was not so troublesome a problem as exposure to heat, but some difficulties were encountered. After the Syrian campaign when troops of the Australian Corps occupied Syria as a fortress area, two winters were experienced. The cold in the mountain areas was sometimes severe and occasionally units were snowed in for a period.

The D.D.M.S. of the I Australian Corps in October 1941, issued detailed precautions to avoid trench foot and frost-bite. These in the main were regular exercises, changes of dry clothing, frequent inspections of the feet with protective applications of powder and oil, and the use of gum boots. Occasional instances were seen of trouble due to exposure to cold, but these were not serious.

In the Western Desert during the first Libyan campaign and in Syria, severe cold was encountered at night, and occasional instances of mild frost-bite were seen. Frost-bite was occasionally seen among men in German prison camps in Poland. Cold was also an occasional problem to be faced in the navy, but here, adequate protection against the winter was available as usual.

In the air force the same problem was encountered as in all air forces, that of coping with low temperatures with high elevation. These matters are dealt with in the Royal Australian Air Force Medical History.

It may be pointed out here, however, that in the transport of sick by air, cold was not unimportant. This was particularly so with sick men coming from tropical areas. When they were exposed to cold and a relative degree of anoxia, they suffered considerable discomfort. The lowered metabolism associated with oxygen lack and the interference with peripheral circulation and the loss of body heat by radiation, combined to produce unpleasant and sometimes even dangerous results. Such problems were met in the early days of air evacuation, as is told elsewhere. It should be noted also that the discomforts of cold in air travel at a fairly high elevation troubled not only the sick but the healthy. Soldiers transported by air often showed the need for a greatcoat by their blue shivering appearance even in the tropics.

Of course, these conditions could not compare with the severity of those encountered by aircrews flying at really high elevation, but the factor is one of considerable importance in relation to the sick. Though the subject of anoxia will not be dealt with in further detail here, it has become a very important environmental condition, not only in war but also under conditions of commercial flying.

### *MOTION SICKNESS*

During the earlier days of the war, motion sickness was more important with navies and air forces than with armies, but with the development of combined operational manoeuvres it became very important to assault forces. In the Royal Australian Navy a special technical instruction was issued on sea sickness. In this was pointed out that the period required for adaptation is variable but is usually not less than three weeks. The percentage of those permanently un-adaptable to the effects of motion of a ship is given as only 5 per cent. General instructions were given including the advice that when early signs, such as pallor, yawning and sighing are noted, the man should be placed on some task requiring mental concentration and kept at work. The wearing of two abdominal belts, tightened over a pad, were also advised, and the instruction concludes as follows:

"As soon as any nausea is experienced—
Tighten the belts.
Refrain from smoking.
Find an interesting job to do or game to play, preferably in the fresh air and to windward of the galley and as near a point two-thirds aft as possible.
Reading a book is not good enough.

If nausea increases, watch the land or the horizon rather than the sea
Keep moving and do not lie down, except to sleep.
close at hand.
Walk about with the legs well apart.
Barley sugar may help if taken early.
In general, keep the stomach as full as possible with fruit, plain biscuits, strong tea or coffee.
Sling your hammock athwartships if possible.
If really sick it is too late for medicines.
Don't go to the Sick Bay, as the M.O. is probably sick too."

Special procedures were advised with soldiers in assault craft immediately before landing, and detailed instructions were supplied.

The most effective drug for the relief of seasickness has been found to be hyoscine, about one-hundredth grain of the hydrobromide, alone or in combination with hyoscyamine. Most of the effective remedies contain some such preparation. No extensive experience was gained in the use of hyoscine in combination with one of the special barbiturate drugs, such as "V-12" (ethyl $\beta$-methylallyl-thio barbituric acid). One difficulty found in landing barges was that of ensuring fresh air to men who were crowded together and often out of range of the breeze. For short trips of this description the amount of protection afforded by drugs of the hyoscine group was generally considered to be in the region of 80 per cent. A preliminary dose before embarkation repeated in six hours was often used: no drowsiness or affection of sight was observed.

Air sickness has engaged the attention of all air forces. In the Royal Australian Air Force it was found that many trainees so affected in their early days soon lost their tendency to be upset by the unaccustomed movements of an aircraft in rough weather. Squadron medical officers could obtain hyoscine hydrobromide in tablets containing 0.75 milligrammes which were found effective. An interesting point concerning the transport of the sick and wounded by air is that those who are severely ill were found to be seldom affected by travel sickness.

### *SOLAR RADIATION AND EYESIGHT*

The effects of glare in the Middle East have been mentioned briefly in the section on ophthalmology, particularly with regard to its effect in making manifest discomfort due to refractive error. The R.A.A.F. took special interest in "surface brightness" as it was sometimes defined. R. K. Macpherson, working under the direction of Professor D. H. K. Lee of Brisbane, measured the surface brightness in several places in the South-West Pacific Area a little north and south of the equator. It was found that the surroundings had an effect often more important than latitude. White coral landing strips reflected light of an intensity almost as great as that from white cloud. Looking upwards usually produced glare more readily than looking down. It appeared that many factors had to be taken into consideration, such as the various kinds of radiation which might affect the eyes, including infra-red and ultra-violet rays, the existence of

contrast relief in the surroundings, the pigmentary equipment of the eyes, and lastly the mental attitude of the observer.

The subject though interesting medical officers caring for men on land, at sea and in the air under the unusual hazard of war is of special importance to the air force medical service.

Harmful effects from solar radiation causing photo-retinitis have been observed in servicemen and women, particularly those engaged on aerial lookout work. These are described in the section on ophthalmology.

### *PSYCHOLOGICAL EFFECTS OF ENVIRONMENT*

Too much has been made of the effects of environment on the mental state of men on active service. The physical environment *per se* may of course be such as to favour malnutrition, fatigue or loss of sleep; it may afford greater risk of infectious disease; it may inflict considerable or even great bodily discomfort; but a good personality in the individual and good handling of the human community by its leaders should foster that high spirit which triumphs over hardships. It is of course desirable that men should not be left too long in isolated and uncomfortable places without relief, especially if they have too much or in particular too little to do. The moral environment is more productive of psychiatric disorders than the physical; it is particularly harmful for men to feel that their work or even their presence in a distant place is of little or no value. Yet most of the men who blame their surroundings for their mental incapacity are in truth unable either to support monotony, and restricted amenities, or to counter these evils by their own efforts. It is regrettable in current speech to use dangerous labels such as "tropical neurasthenia" or even the colloquial "troppo".

The navy furnishes proof of the value of the team spirit. Examples of this were seen in small ships particularly. For instance the crew of H.M.A.S. *Arunta* had perforce to live constantly on board for nearly a year, in the tropics, with no shore leave save during one period of a few weeks. This was necessary because of the prevalence of tropical diseases ashore, and although some of the three hundred men on this destroyer showed signs of mental and physical strain before they were relieved, efficiency was maintained under these trying conditions.

### *APPENDIX*

#### *Effects of Heat*

The clinical conditions grouped under the above heading are dependent on high air temperature and may occur apart from the direct rays of the sun, as in the boiler rooms of ships, in mines, and even in barrack rooms and tents under exceptional conditions. Quite commonly the attack may start during the night several hours after sunset.

Important contributory causes are high relative humidity (wet bulb reading over 83°F.) and air stagnation, both of which interfere with the normal evaporation of sweat.

Other important predisposing factors are:—

(i) Deficient fluid intake. The fluid lost by sweating is not made good and dehydration results. This in turn leads to deficient or absent sweating, a most important factor in the causation of heat hyperpyrexia.

(ii) Deficient blood chlorides, due to a combination of:
(1) Deficient salt intake.
(2) Excessive sweating (most of the salt is lost in the sweat).
This again predisposes to diminished or absent sweating. (Clinical evidence of deficient blood chlorides is given by reduced or absent urinary chlorides).

(iii) Unsuitable clothing and housing.

(iv) Metabolic upsets, especially when associated with excessive alcoholic intake.

(v) Debilitating diseases.

(vi) Marked fatigue, often brought on or aggravated by strenuous exercise during the heat of the day.

(vii) Pyrexia from any cause, especially if associated with malaria.

(viii) Constitutional inability to sweat; also prickly heat and certain chronic skin conditions (i.e. ichthyosis).

(ix) Endocrine imbalance, especially increased thyroid and suprarenal activity (mild hyperthyroidism is common among young people recently arrived in a hot country).

(a) Clinical Varieties

Two major clinical groups must be distinguished.

The first, *heat hyperpyrexia* (classical heat stroke or thermic fever), is directly dependent on heating up of the body to a dangerous level and is usually preceded and accompanied by absence of sweating as an essential cause of the condition.

The second, *heat prostration,* results from a combination of:
(1) Dehydration, and
(2) Salt deprivation (Hypochloraemia).

The body temperature may be subnormal and the skin moist.

Cases of mixed etiology (i.e. collapse with high rectal temperature) are not uncommon; also, cases of heat prostration may develop hyperpyrexia and, conversely, cases of hyperpyrexia may suffer from collapse.

(i) *Heat-Hyperpyrexia,* a "sthenic" condition, usually of sudden onset, which may or may not have been preceded by prodromal symptoms. Is usually accompanied, if severe, by marked cerebral symptoms, and there may be an initial epileptiform seizure, or series of epileptiform attacks (occasionally terminating in *status epilepticus*). Coma or intense lethargy rapidly passing into coma; stertorous, often Cheyne-Stokes, respiration; cyanosis, which may be extreme; bounding, high tension, "cerebral" type of pulse; absent knee jerks, up-going plantars, all point to severe cerebral mischief. Accompanying these urgent clinical phenomena we have a dry burning skin and a markedly raised body temperature (i.e. 106°-110°F.), the extent and duration of which is of prime prognostic significance.

Many sub-varieties of heat-hyperpyrexia are described having relation to the chief presenting symptom, i.e.
(1) Asphyxial.
(2) Paralytic.
(3) Psychopathic.
(4) Heat Cramp.

A combination of (1) and (2) is common.

*Heat Cramp,* the result of dehydration and salt-loss, is specially liable to attack those (i.e. stokers on ships) in whom the heat-stroke has been preceded by intense and prolonged sweating.

Many minor cases of "heat stroke", grouped under the general term "effects of heat", are admitted throughout the hot-weather season. The chief symptoms are headache, often severe, dry, non-sweating skin, moderate fever (102°-104°F.) constipation, dysuria and frequency of micturition. Unfortunately this diagnosis is also

used during the summer months as a "scrap heap" for a variety of indefinite clinical conditions.

(ii) *Heat Prostration,* an asthenic condition, less dramatic in onset than heat hyperpyrexia and often occurring in debilitated individuals, is a state of clinical shock. Dehydration, due to excessive sweating, and hypochloraemia, mainly due to the same cause, are the chief factors in its etiology.

The chief symptoms are those usually associated with marked collapse: cold clammy skin (in contrast to the hot dry skin of hyperpyrexia), shallow sighing respirations, rapid thready pulse, often imperceptible at the wrist. The surface temperature is usually subnormal (95°-97°F.), although the rectal temperature may be high. In most serious cases, there is evidence of intense dehydration and of marked hypochloraemia (causing cramps in the limbs). The blood pressure is low; the skin is inelastic, and there is usually marked haemo-concentration. The patient may or may not have a clouded consciousness and be in a state of clinical "faint" but there is never the deep coma seen in severe cases of hyperpyrexia.

Minor instances of this condition, known as heat exhaustion (fainting in the ranks on a hot day, etc.) are common throughout the summer months (even in temperate climates), but the severer grades are just as urgent emergencies as the more florid cases of classical heat-stroke.

### (b) Prodromal Symptoms

Although both varieties of "Effects of Heat" may occur "out of the blue" in apparently healthy individuals they are more likely to attack those debilitated by disease or other cause, or suffering from a febrile illness, especially malaria.

Prodromal symptoms precede the acute attack by hours or days in a proportion of cases, and are, when present, valuable sign-posts. Amongst common prodromata may be mentioned:

(i) Inability to sweat—an early and important symptom especially of heat hyperpyrexia.
(ii) Headache and/or drowsiness.
(iii) Temperamental changes (i.e. increased irritability)—valuable early sign when present.
(iv) Frequency of micturition, dysuria.
(v) Diminished urinary chlorides, an objective sign of great importance (less than 200 mgms. per 100 c.c. of urine and a total of less than 8 gms. in the 24 hours are said to represent the danger line).
(vi) Pain and cramps in limbs (evidence of dehydration and salt loss).
(vii) Vomiting and constipation (also important as predisposing).
(viii) Anorexia.
(ix) Rapid pulse, contracted pupils, absent or diminished knee jerks (said to be a valuable early sign).

### (c) Differential Diagnosis

Many diseases and conditions (including almost the whole range of "cerebral catastrophes") may, at the outset, be clinically indistinguishable from "heat-stroke", but malaria, especially "cerebral" malaria, is by far the most important. Malaria may closely simulate or complicate both heat hyperpyrexia (malarial hyperpyrexia and cerebral malaria) and heat prostration (algid malaria).

Blood smears should be taken, and examined for malaria in all cases, and, unless malaria can be definitely excluded (the result of one negative blood smear is not sufficient evidence) the safest procedure is to give an intravenous injection of quinine, taking special precautions against increasing the already present collapse (see under treatment paragraph (d) ).

### (d) Treatment

This necessarily varies according to the clinical variety. In all cases, immediate removal to the coolest available location (i.e. heat-stroke centre if available) is necessary.

(1) *Treatment of heat-hyperpyrexia.* Rectal temperature should be taken in all cases (a body temperature over 108°F. is said to kill within the hour). The urgent necessity is to reduce the body temperature as rapidly as possible below the danger level. This may conveniently be done by laying the patient on an iron bedstead or charpoy with a light mattress or permeable matting intervening. His naked body is then sprayed with ice-cold water from an over-head douche (rubbing with ice is not advised). The body temperature should be carefully watched during this process and no further reduction of temperature should be attempted once it has been reduced to a safe level (i.e. from 109°-104°F. from 106°-102°F.). If too rapid and too great a reduction of temperature is attempted grave collapse may ensue.

If the surrounding air is saturated with moisture (i.e. relative humidity round 90% to 95%) it may be impossible to promote sweating by these means. The patient may then be put in a bath of cold, but not too cold water. Ice to the head and an ice-cold enema are valuable adjuvants in severe cases. Attempts to produce sweating by antipyretic drugs, e.g. pilocarpine, are dangerous and should not be attempted.

If, in spite of these measures and the reduction of temperature the patient remains deeply unconscious and cyanosed, with stertorous breathing, the removal of 15-20 oz. of venous blood and its replacement by normal or hyper-tonic saline solution with 5% glucose is often effective.

In the event of circulatory failure, coramine or digitalin (not strychnine, which is a convulsant) may be given.

Respiratory failure, a not uncommon event, should be treated by artificial respiration, prolonged for several hours if necessary. If coma persists for several hours, lumbar puncture and the removal of 10-20 c.c. of C.S.F., if under pressure, may relieve this symptom. (Lumbar puncture should not be attempted too early. The whole brain is oedematous in the early stage, and it is only later that the fluid in the sub-arachnoid space is under pressure. Lumbar puncture too early may, by producing a "pressure cone" be itself the direct cause of death by paralysing the vital centres in the medulla).

It is important to keep a careful watch on the temperature of apparently recovered cases, since recurrence of hyperpyrexia with its accompanying symptoms is by no means uncommon and may lead to a fatal issue. Don't keep patient too long lying on back or hypostatic congestion of lungs may result. Turn on side or face frequently.

(ii) *Treatment of Heat Prostration.* If of severe degree the urgent need is for restorative measures and for the replacement of fluid, and especially of salt lost by excessive sweating. Unless the body temperature is high (estimated by thermometer in rectum), there is obviously no need to reduce the temperature, often the reverse, and a blanket and hot water bottles may be required. Coramine may be given to conscious patients for its stimulating effect. If able to do so the patient should be encouraged to drink large quantities of weak saline drink (¼ teaspoon of salt to the pint of water or imperial drink). If the condition is serious and especially if marked dehydration is a feature an intravenous infusion or normal (or hypertonic) saline solution with 5% glucose is urgently called for.

In either condition, if it is considered necessary to give intravenous quinine, precautions should be taken against aggravating the state of shock which may already be present. In collapsed cases, especially if there is much dehydration, the quinine (8-10 grains) is best given in 1-2 pints of normal saline with 5-10% glucose, to which has been added and well mixed with it 10 m.ms. of adrenaline or 1/2 c.c. of pituitrin. In collapsed cases all infusions should be given at blood heat.

(iii) *After Treatment.* Rest in a quiet darkened room. Cases of hyperpyrexia, especially, should not be allowed up too early or intractable headache may result. Headache best treated with luminal or bromide. Heat-stroke cases are particularly susceptible to hot weather conditions and should, if possible, be sent to a cool climate for the remainder of the summer. Alcohol should be avoided.

(iv) *Heat-Stroke Stations.* These are advisable in certain localities (i.e. large camps and hospitals) during the hot summer months. They are for the urgent treatment of all cases of "Heat-Stroke" in the vicinity and should therefore be

centrally placed and sited in a relatively cool locality. There should be a trained orderly in constant attendance during spells of hot weather and a daily provision of ice should be ensured. The position of the station should be known to all ranks and the medical officer on duty should be within easy call. The equipment varies according to the size of the station, distance from hospital, where partially recovered cases can be transferred, etc.

(e) Prophylaxis

(i) Simple lectures to all ranks on the causation of heat-stroke and its prevention should be given before the onset of hot weather conditions.

(ii) A careful look-out by medical officers for men exhibiting prodromal symptoms (examine urine for diminished or absent chlorides in doubtful cases).

(iii) All strenuous exercise reduced to a minimum during the heat of the day. N.B. This does not mean that men should remain cooped up in darkened barrack rooms with little to do but lie on their beds and meditate many hours during the day. They are far better employed performing light duties in the open, in the shade, if possible.

(iv) If strenuous exercise in the hot sun with consequent excessive sweating is unavoidable, men should be encouraged to drink weak *saline* drinks (salts ¼ teaspoon to the pint of water or weak tea) to replace fluid and salt lost by sweating.

(v) Importance of avoidance of alcohol during the heat of the day to be impressed on all ranks.

(vi) Clothing should be light, permeable, and loose, to allow free ventilation of the body surface.

(vii) Careful routine attention to and cleanliness of skin. The use of a simple dusting powder over parts liable to sweat.

(viii) Enforcement of careful march discipline, e.g.:

(1) Ventilation of ranks when marching (i.e. changing files after each halt; opening up on either side of road when possible).

(2) Full use to be made of halts for resting and cooling.

(3) Water bottles to be used only at halts, and then just sufficient weak saline water (or weak saline tea) consumed to replace fluid and salt loss.

N.B. The drinking of large quantities of unsalted water is harmful. It gives no great relief from thirst and tends to make men vomit.

(4) Long marches during the heat of the day to be avoided or reduced to a minimum. If unavoidable, men should drink weak saline water or weak saline tea.

(ix) Hospital precautions during hot weather.

(1) Heat-stroke stations prepared beforehand when considered necessary.

(2) Operations and anaesthetics reduced to a minimum during the heat of the day.

(3) Careful and frequent checks of temperature of all patients in hospital, especially febrile cases (malaria). A mounting temperature in an already febrile patient may be a danger-signal of impending heat-stroke.

(4) Certain drugs, i.e. atropine (reduces sweating); thyroid (increases metabolism), strychnine (convulsant) are best avoided or reduced to a minimum.

(5) Individuals with constitutional inability to sweat are in special danger of heat-stroke and may have to be retained in hospital throughout the hot weather or sent to a cooler climate.

## *REFERENCES*

C. E. CORLETTE, *Med. Journ. Aust.*, 18 Oct. 1941.
J. M. FLATTERY, *Med. Journ. Aust.*, 2 Jan. 1943.
J. WITTON FLYNN, *R.A.A.F. Med. Newsletter*, Bull. No. 11, 1 Aug. 1945.

K. G. HEARNE, *Med. Journ. Aust.*, 13 Feb. 1932.
W. S. S. LADELL, J. C. WATERLOW and M. F. HUDSON, *Lancet*, Oct. 14 1944; *Lancet*, Oct. 21 1944.
D. H. K. LEE, R. E. MURRAY, W. J. SIMMONDS and R. G. ATHERTON, *Med. Journ. Aust.*, 6 Sept. 1941.
G. W. MOLNAR, et alii, *Am. Journ. Hyg.*, Nov. 1946.
G. NEWMAN MORRIS, *Med. Journ. Aust.*, 14 Oct. 1944.
J. P. O'BRIEN, *Arch. Int. Med.*, Jun. 1948.
War Office Army Dept., *Med. Bull.*, 6 Mar. 1943.
D.G.M.S., Army, *Tech. Instr. M.E.*, No. 11.
D.N.M.S., R.A.N., *Tech. Instr.*, No. 9.