hospitals, for instance, the great majority of the patients are on full diet, and there are few, if any, spare rations.

Summary

The rations for each important section of the population have been evaluated and compared with the League of Nations scale of requirements. The comparison is summarized above.

In those instances where the yield of nutrients from the rationed foods is less than requirements, suggestions are made for meeting the deficit by one or more of the following, having regard to prevailing dietary habits: (a) consumption of unrationed foods; (b) canteen and similar meals; (c) exchange of points into B.U.s; and (d) the family pool.

In making these suggestions attention has been confined to energy requirements, because experience of wartime diets has shown that, given the full rations, the additional unrationed foods necessary to satisfy energy requirements also provide, or almost provide, a sufficiency of all important nutrients.

It has been found that the filling of the gap should present no great difficulty for the great mass of the population, who can, if necessary, supplement their rations from (b) and (c) sources; but it may not be easy for adolescent and other males whose requirements are above the average for their class and who are not entitled to special rations and cannot supplement their diet from sources (b), (c), or (d).

A SIMPLE FORMULA FOR THE CALCULATION OF ATMOSPHERIC DRYNESS

BY

R. L. WYNNE, M.B., M.R.C.S., D.A.

Anaesthetist, Birkenhead General Hospital

The following case, though an extreme one which occurred during the stresses of wartime, illustrates the fact that in British practice too little attention is usually devoted to the atmospheric conditions of operating theatres. They often get too hot, not only in summer-time but also in winter, when central heating is operated with more enthusiasm than discretion, and their humidity tends to rise with the addition of steam from sterilizers. The control of these conditions should be especially cared for in a place where the working staff are expected to maintain a high standard of mental alertness, and where the heat-regulating functions of the patient, like all the functions of his nervous system, are set in partial abeyance by anaesthesia.

Case Report

During the war an underground hospital was built with a view to its use in emergency. An anaesthetist was asked to comment on the suitability of the operating theatre it contained. The ventilation was far from efficient, and when the sterilizers were in operation and several people were working in the theatre the atmosphere became extremely hot and moist. The anaesthetist in his report pointed out that patients when anaesthetized tended to become poikilothermic, and that in such an atmosphere complications—for example, ether convulsions due to the breakdown of thermal equilibrium—would be likely. This report was not taken very seriously, and later the anaesthetist was required in circumstances which admitted of no denial to set to work in this operating theatre. Some 30 cases were operated on successfully. One day a man was brought in for operation on bilateral inguinal herniae.

He was a ship steward aged 31. His temperature was normal, pulse 60, respirations 18, and blood pressure 120/80. He had no history of previous illness. He was a perfectly healthy man except for the herniae which he wished to have operated on. After preliminary medication with omnopon and scopolamine, anaesthesia was induced by 0.75 g. of pentothal, and continued by 6 litres per minute of gas and oxygen (the latter in 25% concentration) with ether. After half an hour he was seen to be sweating profusely, as indeed everyone in the theatre was, and the volume of his respiration started to increase. The thermometer hanging on the wall registered 81° F. (27.2° C.)

and the atmosphere was very moist. The total volume of gases delivered to the mask was increased to 12 litres per minute, still in 25% concentration, and after 45 minutes ether was discontinued. After 55 minutes the patient was red and sweating, the hyperpnoea was no better, and his pulse had risen to 126. The hernia on the right side was finished in 60 minutes, and at the request of the anaesthetist the operation on the other side was abandoned. On the patient's return to the ward his temperature was found to be 106° F. (41.1° C.), and his pulse 160. Cooling treatment was given, and oxygen and CO₂ administered. Within an hour he was dead. At necropsy no appearances other than those of heat-stroke were found. The underground theatre was not thereafter used.

Noteworthy features of this case are: (1) it was a case of pure heat-stroke, unaccompanied by any sign of convulsions; (2) there was no question of sweating being impaired by atropine; (3) there was no question of anoxic anoxia; (4) if the hyperpnoea led to any serious degree of CO₂ deficiency, this was combated by the administration of CO₂ in mixture; (5) there was no question of sepsis or pre-existing fever.

Calculation of Drying Capacity of Air

Moisture in the atmosphere is usually estimated by means of the "wet- and dry-bulb thermometers," which when exposed to an atmosphere not entirely saturated with water vapour will show readings differing by a certain number of degrees. The lower temperature of the wet bulb is caused by abstraction of heat in the process of evaporation of some of the water covering it. For scientifically accurate results the thermometers must be subjected to considerable air movement, and in America the "sling-psychrometer" is used for this purpose. The instrument is whirled through the air at a considerable velocity on the end of a sling. In England the usual open-air method is to expose the thermometers in a Stevenson screen, by which they meet with a slighter movement of the air; and in indoor conditions the thermometers are simply hung in a room in comparative calm.

The partial pressure of the water vapour contained in the air may be expressed in millibars by the empirical formula:

$$P = S^w - f \Delta$$

where P is the actual pressure in millibars of water vapour in the observed conditions, S^w the pressure at saturation point at the temperature of the wet bulb, Δ the difference in Fahrenheit readings between the two thermometers, otherwise termed the "depression," and f is a constant which depends on the pressure and velocity of the air passing over the bulbs. When using the sling psychrometer the value of this constant is 0.367; in England, for use with the Stevenson screen, the Air Ministry have adopted the value of 0.444. In the calm and not very precise conditions of thermometers suspended in interiors the round value of 1/2 is probably accurate enough.

The values of the partial pressure of water vapour under saturated conditions at various temperatures are well known,

The continuous line follows the true curve; the broken line indicates the curve: $y = \frac{1}{100}x^2 - \frac{1}{2}x + 12$.

and have been plotted in the form of a curve in the accompanying figure. When these values are expressed in degrees Fahrenheit and millibars, it will be seen that the curve of saturation pressures between the temperatures 30° and 90° has a remarkable similarity to the parabola:

$$y = \frac{1}{100}x^2 - \frac{1}{2}x + 12.$$

The greatest error introduced by using this equation occurs in the neighbourhood of 76° F., at which the true value of the saturation pressure is 30.66 millibars, and the value calculated by the equation is 31.76, an error of a trifle over 1 millibar. Elsewhere this error decreases, and at three points over the indicated range the calculated value coincides with the true value.

Using the equation, one may write:

$$S^w = \frac{1}{100}W^2 - \frac{1}{2}W + 12$$

where W is the temperature Fahrenheit of the wet bulb. Hence, from the formula $P = S^w - f\Delta$, and taking $f = \frac{1}{2}$,

$$P = \frac{1}{100}W^2 - \frac{1}{4}W + 12 - \frac{1}{4}\Delta.$$

But $\Delta = D - W$, where D is the temperature Fahrenheit of the dry bulb, and the formula thus becomes:

$$P = \frac{1}{100}W^2 - \frac{1}{2}D + 12.$$

Partial saturation of the atmosphere by water vapour is usually expressed in terms of "relative humidity," which is the ratio of its actual vapour pressure to the pressure which would be attained by saturation at the same temperature, expressed as a percentage. Using the term H for relative humidity, and S^d to express the saturation pressure at the temperature of the dry bulb, one may thus write:

$$H = 100 \frac{P}{S^d} = 100 \frac{\frac{1}{100}W^2 - (\frac{1}{2}D - 12)}{\frac{1}{100}D^2 - (\frac{1}{2}D - 12)}$$

Thus, as may be seen, to estimate the relative humidity the only figures required are the squares of the thermometer readings, each divided by 100 and diminished by half the dry-bulb reading less 12. For example, if the dry bulb reads 60° F. and the wet bulb 55° F., half the dry-bulb reading less 12 will equal 18, and subtracting from each of the squares the relative humidity is found to be:

$$100 \frac{30.25 - 18}{36.00 - 18} = 68\%.$$

If the dry bulb reads 71° F. and the wet bulb 67° F., the relative humidity is found to be:

$$100 \frac{44.89 - 23.5}{50.41 - 23.5} = 79\%.$$

The relative humidity is, however, not a very valuable figure if, as is usually the case, it is desired to estimate the capacity of the air to absorb moisture, since the total capacity of the air varies greatly at different temperatures, and at low temperatures is so small that even a small relative humidity does not indicate a great residual ability to absorb moisture.

For practical purposes the drying capacity of the air is better expressed as the "saturation deficiency," or the number of millibars by which the partial pressure of the water vapour actually present falls short of the saturation pressure at the same temperature. This figure, expressed in terms of the equation, becomes:

$$\begin{aligned} S^d - P &= (\frac{1}{100}D^2 - \frac{1}{2}D + 12) - (\frac{1}{100}W^2 - \frac{1}{2}D + 12) \\ &= \frac{1}{100}(D^2 - W^2) \\ &= \frac{1}{100}(D + W)(D - W). \end{aligned}$$

The above expression, which might be called the "index of drying power" of the air (and approximates the true value of the saturation deficiency in millibars), thus becomes a figure which can rapidly and easily be calculated direct from the thermometer readings without the help of tables, should these not be available. For example, the thermo-

meters might show readings of 50° F. and 45° F. Multiplying the sum by the difference, and dividing by 100, the index of drying power is found to be 4.75. In another place they might show 75° F. and 68° F.; by the same calculation the index is found to be 10.01. In the second case, though the depression of the wet bulb is only 2° F. greater, the air has more than twice the drying power.

Discussion

Wet- and dry-bulb thermometers are rarely seen in operating theatres; but I would suggest that were they more commonly used, and the proposed simple calculation of the index of drying power carried out from time to time in conjunction with readings of the dry bulb, the results might in many cases prove illuminating. The importance of the wet-bulb temperature was long ago pointed out by Haldane (1905), who found that, whatever the dry-bulb temperature, heat-regulation would begin to break down when the wet-bulb temperature rose above 88° F. (31.1° C.). Probably 70° F. (21.1° C.) should be regarded as the upper limit of safety in an operating theatre.

The hazards of hot and moist atmospheres have been emphasized, but those at the other extreme are scarcely less important. Cold surroundings will produce or aggravate surgical shock, and a very dry atmosphere will facilitate the production of high static electrical potentials, with a corresponding risk of explosion of inflammable vapours. Such dryness is but rarely encountered in Great Britain, but I have on at least one occasion heard the crackle of a static discharge in a theatre when a dry blanket was quickly pulled away from a trolley.

The formula ($P = S^w - f\Delta$) and the figures for partial pressures are taken from the Air Ministry Hygrometric Tables, M.O. 265 (1940), published by H.M. Stationery Office, and I have to thank the Director of Bidston Observatory for drawing my attention to that useful publication.

Summary

It is pointed out that an assessment of the drying capacity of the air can be made by a no more complicated procedure than finding the product of the sum and difference of the wet- and dry-bulb readings.

It is suggested that the atmosphere of operating theatres should be more rigorously investigated and controlled.

BIBLIOGRAPHY

- Beecher, H. K. (1938). *The Physiology of Anesthesia*, Chap. 4, Oxford University Press, London.
Haldane, J. S. (1905). *J. Hyg., Camb.*, 5, 494.
Smith, F. W. G. (1934). *British Medical Journal*, 1, 77.
Woolmer, R. F., et al. (1936). *Lancet*, 1, 1005.
Wright, A. D. (1933). *British Medical Journal*, 2, 1210.

TRAUMATIC URAEMIA: RECOVERY

BY

J. C. SCOTT, M.S., F.R.C.S.

AND

C. G. ROB, F.R.C.S.

(From the Radcliffe Infirmary, Oxford)

Below is reported a case in which a penetrating wound of the right thigh with division of the femoral artery and vein, without any apparent injury to the abdomen or left leg, led to an ischaemia of both legs. This was followed by a great increase of blood urea and other signs suggesting the onset of traumatic uraemia. After splanchnic block the blood urea fell and the general condition improved sufficiently to permit amputation of both legs. Following amputation progress was uninterrupted. Trueta and others (1946) suggest that splanchnic block should prove of value in