The professor of anatomy who receives the body is responsible for its preservation until it is ready for burial. This is conducted by a clergyman of the faith which the deceased professed during life, and the burial certificate, with full information, is sent to the Inspector of Anatomy, who transmits the particulars to the person who originally authorized removal of the body for this purpose. It may be noted that a funeral service may be held before the removal of the body or, of course, a memorial service in the absence of the body.

All expenses connected with the removal and a simple funeral are borne by the medical schools. Bodies may be left to a particular medical school, but it is more desirable that testators should not express such a wish and should allow their bodies to be sent to the medical school which is most convenient at the time of death. The forms required are (1) a medical certificate of the cause of death; (2) in the London area, a notice to the Inspector of Anatomy to remove the body, to be signed by the next of kin or executor; in the Provinces and in Scotland, a similar form with, in addition, a form to be sent to the professor of the medical school concerned. Should the forms not have been obtained during life, or be inappropriate, or have been mislaid, they can, of course, be obtained by the next of kin or executor as set out below.

To sum up, persons intending to bequeath their bodies for anatomical dissection should (1) ascertain so far as is possible that no objection will be raised by the nearest relatives; (2) place with their papers a written statement of their intention; (3) apply for the necessary forms and instructions to H.M. Inspector of Anatomy at the Anatomy Office, Ministry of Health, Whitehall, S.W.1 (for England and Wales), or the Anatomy Office, St. Andrew's House, Edinburgh (for Scotland).

Although it is clear that the number of subjects derived from "bequests" cannot replace entirely the number derived from unclaimed persons dying in institutions, yet I am convinced that, if more was known in our profession and by the public of the need for, and the conditions of, this method of disposal, the proportion of "bequest" subjects might be considerably increased. In this connexion, I venture to suggest that students should not become qualified without having some idea of the derivation of the bodies which they have dissected during their course on anatomy and operative surgery, and that it is desirable that teachers of anatomy should spend a few minutes giving to each of their classes a short talk on this subject. After all, the most effective answer to criticisms is that doctors themselves are willing to give their own bodies for this purpose.

ESTIMATION OF HEAT RADIATION IN CLINICAL PRACTICE

BY

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Whereas a great deal of work has been done on developing the quantitative administration of x rays and radium rays, the administration of infra-red radiation for clinical purposes still relies to a great extent on guesswork. The reason for this discrepancy is twofold. In the first place, as we shall see presently, the problem of exercising quantitative control over the administration of infra-red radiation is far more complex than in the case of x rays. Secondly, heat radiation is considered harmless, since overdosage is registered almost instantaneously by pain, whereas overdosage of x or radium rays is insidious, their effects not becoming apparent until some time after administration. It must be remembered, however, that weak sources of infra-red radiation are probably of little clinical value, and that powerful radiators producing definite clinical effects are by no means harmless. For example, cases have been recorded in which burns have been inflicted on unconscious patients, and even when the patient is conscious there may

be a general overheating of the body and disturbance of the circulation. It is the aim of this paper to define clearly the physical problems underlying the quantitative clinical administration of heat rays and to offer suggestions for the solution of these problems. We do not wish to discuss at this stage the physiological effects of the various kinds of infra-red radiation; our aim is rather to put into the hands of the medical practitioner the means of controlling this radiation in a quantitative and reproducible way.

Setting out the Problem

The heat rays used in clinical practice are electromagnetic vibrations like x rays, ultra-violet, and visible light, and are only to be distinguished from these radiations by their greater wave-length. The various radiators used in clinical practice all emit rays with a wave-length ranging from that of visible light (roughly 0.5μ) to the far infra-red with a wave-length of 8μ or more. The particular distribution of the radiated energy over the various wave-lengths—i.e., the *quality* of the radiation—depends in each case on the nature of the source, and in particular on its temperature and the character of its surface. Any hot body acts as a radiator. Its radiation is spread over all wave-lengths, but the wave-length in the neighbourhood of which the greater part of the energy is emitted depends on the temperature of the body. The hotter the body the shorter is this wave-length. Fig. 1 shows the energy emitted from 1 sq. cm. of a blackened surface at two different temperatures.

FIG. 1.—The radiation from hot bodies distributed according to wave-length. The shaded area shows the visible region.

The quality of radiation thus differs from source to source, and while its specification is undoubtedly of considerable importance in clinical applications, our main attention in this paper will be fixed on the primary task of determining the *total* quantity of radiant energy of all wave-lengths received on the skin of the patient. The complexity of the problem, and the way in which it may be subdivided, can be illustrated by the example of the radiant-heat cradle.

The first complication is that, in contrast to x-ray work, there is no definite beam of radiation. A surface element of the skin of a patient under the cradle receives radiation not from one direction alone but from practically all directions. The usual practice of radiology, which defines the quantity of radiation by the flow of energy across a surface placed perpendicular to the beam, thus becomes meaningless. It must be replaced by the specification of *radiation flux*, which is the flow of energy coming from all directions which passes in unit time across a unit area of the patient's skin. This is the only physical quantity which is of importance to the clinician, since it tells him how much radiant energy the skin actually receives; and our efforts must be directed towards its determination by methods suited to clinical practice. The most suitable unit for the measurement of radiation flux seems to be the gramme calorie per square centimetre per minute. This is the same unit as Mayneord and Tulley (1943) proposed for the measurement of "intensity of radiation." The actual magnitude of the radiation flux at a particular point on the patient's skin will depend not only on the distance of that point from each radiating element of the source but also on the orientation of the skin to those various elements.

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Let us now examine the nature of these elements in the case of the radiant-heat cradle. They are, first, the lamps, which emit radiation of a temperature of about $1,800^{\circ}\text{C}$. (carbon filaments), and which may be considered as point sources. Not all their radiation, however, arrives at the skin of the patient, because the glass envelopes of the bulbs absorb all wave-lengths greater than about 3μ . The absorbed fraction amounts to about one-third of the total radiation emitted by the filaments, and heats the glass envelopes to a temperature of about 100°C . Thus the envelopes in their turn become sources of radiation; but since their temperature is very much lower than that of the filaments, the energy distribution of the radiation emitted by them is quite different from that of the absorbed radiation. Finally, the metal background of the cradle is also heated by radiation from the lamps to a temperature of about 120°C , and therefore it, too, acts as a radiator, which, because of its large surface, plays a very important part in producing the flux received on the skin of the patient (Brown, Evans, and Mendlessohn, 1943). If the background is polished the problem is further complicated by reflection of part of the radiation.

Another difficulty, and one of great importance for the clinician, is introduced by the fact that the heating up of the envelopes and the background is a gradual process, which may take as long as several hours. As we shall see, at the end of this time the patient is receiving *three times* as much radiant energy every minute as when the cradle was first switched on. Although we selected the particular example of the cradle because we had studied it closely in previous work, the same problem of complexity presents itself in connexion with practically any form of clinical treatment lamp.

Computation

The difficulties stressed above will make it clear that a numerical computation of the radiation flux received by the patient is a complicated procedure which, even in the simplest cases, requires considerable mathematical skill and laborious numerical calculation. We have in fact carried out such computations for the radiation flux received on a horizontal plane stretching across the cradle at its widest part—i.e., at 7 in. above the base, or roughly the height of the ventral surface of the patient. The results of these calculations, which are shown in Fig. 3 (B) and Fig. 4 (B), will be discussed below. The mathematical details, which are of a somewhat complex character, will be published elsewhere. In contrast, therefore, to x-ray work, computation cannot be advised as a feasible means for the clinician of estimating dosage of radiant heat. Each separate case constitutes quite a considerable problem of mathematical physics, and any error in calculation, or the neglect of any contributing factor, might easily result in a dangerously incorrect estimate of dosage.

Direct Measurement of Radiation Flux

Our efforts will therefore be directed towards the development of an instrument which can be placed at a position which the patient's skin will occupy, and which directly measures the radiation flux. The fact that such an instrument—for which we should like to propose the general name of thermo-radiometer—does not exist serves as an indication that certain difficulties stand in the way of its development. A thermo-radiometer must record the flux of radiant energy received throughout the whole range of wave-lengths emitted by the treatment source. The radiant energy arriving at the receiver surface of the radiometer must be converted into heat, the quantity of which can then be determined by one of several methods. This means that the instrument must register only energy received by radiation, and must not register energy received in any other way. But under any treatment source the air may be warmed, and therefore heat is apt to be transferred to the receiver surface not only by radiation but also by heat conduction through the air.* In scientific determinations

* Practically no quantitative information is available on the question of how great this conduction may be. Certainly it is not related in any simple way to the quantity of heat received by radiation. It should be possible to devise a simple method for determining the quantity of heat received by the skin through air conduction, and the results would be of interest to the physician; but the whole question is a very complex one, and is beyond the scope of a discussion of heat transfer by radiation.

of infra-red radiation this difficulty is often overcome by enclosing the receiver surface in an evacuated envelope, and this method has also been used in attempts to determine radiation flux for medical purposes.

The method is, however, limited by the fact that no material suitable for the construction of the vacuum container is known which is uniformly transparent throughout the whole spectral range. A glass envelope, for instance, as used by Mayneord and Tulley in some of their work, is quite opaque for wave-lengths greater than $3\text{--}3.5\mu$ —a fact which was pointed out by these authors. How seriously this limitation can affect the dosage based on the readings of such an instrument is clearly shown in the case of the cradle, where all the radiation flux coming from the envelopes of the lamps and from the metal background is stopped before it reaches the recording surface, because it is all in wave-lengths greater than 3μ . This means that, although at the beginning of a treatment the patient may be receiving something like the flux indicated by the reading of the instrument, after a lapse of time he will actually be receiving three times as much, though there will have been little or no change in the reading. The acceptance of such readings at their face value therefore introduces a serious danger of overdose.

We have accordingly attacked the problem in a different way. Instead of excluding heat conduction we have employed a differential arrangement in which the energy received by two surfaces is compared. Only one of these surfaces is exposed to the radiation from the treatment source, while both of them receive heat by conduction through the air. Since the distance between the two surfaces is small, the air surrounding them has the same temperature, and the amount of heat received by conduction is the same for both, and cancels out, leaving a direct indication of the radiation flux—i.e., of the quantity which we wish to measure. The physical method by which we determine the amount of heat received by the surface must

FIG. 2a.—Diagram showing thermo-radiometer connected up with millivoltmeter.

FIG. 2b.—Diagram of the thermo-radiometer.

employ some sort of calorimeter. A primary method, for instance, consists in measuring the rise in temperature of a copper block of given weight in a given time. We have indeed used such an arrangement, comparing the energy received by two such copper blocks, the blackened surface of one of which was exposed to the radiation. Observations with such a thermo-radiometer are very useful for the determination of absolute values of radiation flux, but are too time-consuming for clinical practice.

We therefore propose for general use a simpler arrangement (Figs. 2a and 2b), having two receiver plates, R_1 and R_2 , with blackened surfaces, the temperature difference between which is measured by means of a set of thermocouples attached to their reverse faces. R_1 is exposed to the radiation flux to be measured, whereas R_2 is screened from this radiation by the baffle, B. In order to give a constant flux with which the radiation to be measured may be compared, R_2 is placed before a metal screen, A, which is maintained at constant (room) temperature.

When the instrument is used, R_1 is placed in the radiation field at the position which would be occupied by the skin of the patient. R_1 receives the radiation flux which the patient will receive, and R_2 receives a standard flux from A. Both, however, are exposed to the same air conduction. The temperature difference between R_1 and R_2 rapidly becomes steady, and this difference depends only on the flux falling on R_1 , provided the flux on R_2 is kept constant.

The instrument must be calibrated against known radiation fluxes (which may be determined by the primary calorimetric method described above, or otherwise); but, once this has been done, the scale of the millivoltmeter, M, can be graduated directly in units of flux (gramme calories per square centimetre per minute). The physician can therefore read off at a glance the flux which the patient will receive on any part of his skin, simply by placing the little instrument in the position which that part of the skin will occupy.

We have constructed such an instrument, and have checked its readings against the flux received from well-defined radiation sources, and by comparison with the primary calorimeter. The technical details of this work will be published elsewhere.

Using this instrument, we have measured the radiation flux in radiant-heat cradles. The results, which are of considerable significance for the clinical use of these cradles, are shown in Figs. 3 (A) and 4 (A). Each figure is a map of a horizontal plane 7 in. above the base of the cradle, and the results are given in the form of a series of "contour lines," along each of which the radiation flux is constant. At any point on the curve marked "1.5," for example, the flux is 1.5 calories per square centimetre per minute, and at any point between the curves marked "1.5" and "1.6" the flux is intermediate between these two values, and so on. Each map is divided into two halves: the left-hand halves (A) show the values actually measured with our instrument, while the right-hand halves (B) show the values calculated as mentioned above.

FIG. 3.—Distribution of radiation flux under standard heat cradle with blackened background. The flux is that due to the lamps plus that due to the background. Numerals on contour lines give the amount of radiant energy in calories per sq. cm. received in each minute on a plane 7 in. above base of cradle. A=measured values; B=calculated values. Positions of lamps above plane are represented by circles.

Fig. 3 refers to an ordinary cradle with a blackened background, and the flux at each point is therefore the sum of that due to the lamps and that due to the heated background. In Fig. 4 the flux due to the lamps only is shown; experimentally, this was secured by cooling the metal background. Thus Fig. 4 shows the flux

received by the patient immediately after switching on and before the background has had time to heat up, while Fig. 3 shows the very much greater flux received by the patient after the background has had time to heat up and become a source of radiation on its own. The agreement between the measured and calculated values is surprisingly good, and indicates the general correctness both of our line of theoretical reasoning and of our methods of measurement.

A comparison of Figs. 3 and 4 shows that during the course of treatment the flux received by the patient may increase threefold—a fact which brings home the serious danger of overdosage which

FIG. 4.—Distribution of radiation flux under standard heat cradle with blackened background. Background cooled. Flux due to lamps alone. A=measured values; B=calculated values.

may be incurred if the increase of the power of the source with time is not taken into consideration. It may be remarked that the results of Fig. 4 (no radiation from the background) are very similar to those of Mayneord and Tulley (1943), who excluded the long-wave radiation from the background by the glass envelope of their radiometer.

Some other investigations (results not shown) are of interest. The results of Figs. 3 and 4 refer to the case when the cradle is blackened but the bulbs are not shielded, in contrast to the conditions used in work previously described (Brown, Evans, and Mendelsohn, 1943). In one of the additional investigations the flux was determined with the background left polished and kept cool, and with the bulbs unshielded. The conditions were exactly the same as those for the results of Fig. 4, except that rays from the lamps were reflected from the metal background. The results were almost exactly the same as those shown in Fig. 4, which means that the reflection of rays from the polished background is of very little importance in producing the distribution of flux received by the patient.

We also determined the flux in a cradle in which the background was blackened and not cooled, and in which the lamps were covered with thin metal shields. The average value for the flux in this case was about 1 calorie per square centimetre per minute, and the flux was extremely uniform all over the cradle area.

All these results, and particularly the preponderant part played by the radiation from the cradle background, represent a gratifying confirmation of our first rough analysis of the action of heat cradles.

Conclusion

The thermo-radiometer used by us is essentially a laboratory instrument, but it holds out good prospect for development into a simple radiation-flux indicator for clinical use. When this problem of accurate estimation of total flux has been solved the next step must be to devise an instrument capable of differentiating flux received by the patient in different wavelengths—i.e., an instrument capable of assessing the quality of radiation.

Meanwhile, a great deal can be done by an accurate determination of the total radiation flux received under various conditions from standard treatment lamps, and thus to ensure

more reproducible and better-defined conditions of treatment by infra-red rays. There remains, of course, the great and complex problem of the physiological action of heat radiation. Here again the position is much more difficult than in the case of *x* rays. Whereas *x* rays are more or less uniformly absorbed by the tissues, in which they produce chemical changes, the action of infra-red rays results mainly in an increase in temperature produced near the surface of the skin, which is counteracted by perspiration and by dissipation of the local increase in temperature by the circulation. While a certain amount of information as to the penetration of infra-red radiation exists, little is known about the specific action of heat radiation under clinical conditions. As has been pointed out before (Brown and Mendelssohn, 1944), the physiological action of a given type of heat radiation is likely to be quite different in local and in general administration. The greatest need is for clinical observations of the effects of infra-red radiation administered in known quantities and under well-defined conditions, and we hope that the considerations advanced in this paper will aid the clinician in establishing conditions of treatment which will provide a sound physical basis for the study of clinical observations.

Summary

The physical factors involved in the clinical application of radiant heat have been enumerated and discussed. Computation of dosage based on the consideration of the nature of the treatment source is liable to grave error and should be discouraged. Treatment should be based on the direct measurement of radiation flux—i.e., the amount of radiant energy received on the surface of the patient's skin. The methods by which such measurements may be made have been discussed, and one particular radiometer has been described and recommended for clinical use.

Dangerous overdosage may be caused by: (a) neglect of the fact that the radiation from almost all treatment sources increases during the time of application; (b) attempts to determine the flux received by the patient with unsuitable radiometers which yield results far below the true values.

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RADICAL OPERATION FOR VARICOSE VEINS

BY

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To call an operation for varicose veins radical is a substantial claim, especially when the ingenious and occasionally heroic procedures of the past are recalled—e.g., multiple ligatures and excisions, the Trendelenburg operation with and without excision of the prominent veins, the stripping operation, injection therapy, etc. Since 1930 the operation of simultaneous ligature and injection in various forms has been developed and reported (Dodd and Oldham, 1940; Dickson Wright, 1940). I started in 1932, and this article details the position after over 500 operations which a follow-up has shown to merit the term "radical." Since 1939 modified procedures have been described which give good immediate results, but, in my experience and that of others, recurrence takes place in three months to three years, and these easier methods are not advised (Russell, 1941).

The radical operation for varicose veins premisses several factors. First the veins must be varicose—that is, they must be distinguished from compensatory veins which have developed in response to thrombosis of the deep conduits. Then, having decided that the veins are varicose, the type must be diagnosed, so that the correct radical measure can be chosen. There are at least seven varieties of varicose veins which require operation to cure; most of the remainder will respond to efficient injections. The types of varicose veins are diagnosed as follows, depending on incompetence of the valves in or at:

- (1) the termination of the great saphenous vein; (2) the termination of the external saphenous vein; (3) the internal and the external saphenous veins coincidently; (4) the communicating veins between the deep and superficial venous systems of the leg (which normally allow blood to flow inwards); (5) the communicating veins between the deep and superficial venous systems, plus (1); (6) the communicating veins between the deep and superficial venous systems, plus (2); (7) the communicating veins, plus (3).

The radical operation consists in the permanent obliteration of the varicose veins. It is achieved by a combination of ligatures and division at the termination of the internal or external saphenous veins or of the communicating veins, and thrombosis and sclerosis of the varices by injection of an effective and adequate amount of sclerosing agent at the same time. These two factors—i.e., the agent and its volume—are determined by the grossness of the veins to be destroyed.

Radical Operation for Varicosity of Internal Saphenous Vein

This is the commonest presentation, and the plan to be detailed often suffices for the occasional associated incompetence of the communicating veins, particularly those in the thigh.

The Anaesthetic.—A local or general anaesthetic is admirable; a spinal gives pleasantly empty veins and the patient stops in bed for 24 hours. In my practice patients get up the night of the operation, and thereafter morning and evening for lengthening periods, the object being to avoid pulmonary embolism and to keep up muscle power.

The operation necessitates incisions in the groin and at the internal malleolus at the ankle. The grossest veins require a third ligature, injection, and division above the knee. The veins are exposed, tied, and divided, and 20 to 40 c.cm. of 30% saline is injected downwards at the groin and upwards at the ankle. The result is a firm sclerosis of the internal saphenous system, and in some cases of varicose veins in the external saphenous area as well. The thrombosis is palpable before the patient leaves the operating-table, so that the adequacy of the operation is apparent.

Technique of the Operation

The Landmark of the Incision.—The incision runs 1/4 in. below and parallel to the natural fold of the groin. It is 2 to 3 in. long, according to the obesity of the patient. Its centre lies where a line dropped from the pubic spine at right angles to the fold of the groin intersects the incision. The location of the internal saphenous vein is somewhat variable, but this exposure leads immediately to it. The centre of each lip of the wound is seized and forcibly elevated and retracted. This stretches the subcutaneous tissue and makes it possible to cut steadily through the two layers of subcutaneous fascia to expose the vein. The internal saphenous vein—recognized by its large size—is dissected "nude" with the scalpel until its three upper and occasionally one or two downward branches are revealed and also until the inward turn of the main trunk to join the deep femoral vein is defined.

Saphena varices are notoriously friable and are handled fondly like old china. The branches are tied and divided between ligatures. The common femoral vein is exposed sufficiently to ensure that the lower part is patent; the operation is abandoned if it isn't, for then the internal saphenous vein must be compensatory. The end of the saphena magna at its union with the femoral vein is tied with stout thread; to tie it distal to this point leaves a cul-de-sac of vein in which a thrombus can form and pass into the main venous system, with undesirable pulmonary embolism.

An Abnormality.—Occasionally what appears to be the internal saphenous vein is small; this stimulates the search for a duplicate vessel which may lie underneath separated by a layer of fat or occasionally parallel in the same plane of fascia. The common femoral vein, which may be mistaken for it, is recognized by its size, its straightness, the depth at which it lies, and the pulsation of the femoral artery adjoining it. I have once tied and injected the femoral vein, and on two other occasions have had the ligature around it, discovering the mistake only just in time. A good exposure is the best preventive.