affected. It thus seems worth investigating in the future what can be achieved with a lower dosage from the beginning, even though results may be obtained more slowly. It may be possible to avoid untoward reactions in this way. And with clinical application in cases of rheumatoid arthritis it is not always necessary to make the patients reach an optimal condition in a very short time.

In four cases (1, 3, 5, 6) it was possible to maintain the clinical remission with 6×2 mg. In three cases (1, 5, 6) the dose was lowered to 6×1 mg. a day; in all three the result was a relapse. Two patients (2, 4) had a recurrence of signs and symptoms with a higher dosage (6×10 mg. and 6×7 mg. respectively). Both were serious cases complicated by other affections.

Summary

Five patients with rheumatoid arthritis and one with ankylosing spondylitis have been treated with A.C.T.H. in low dosage over a period of two to six months.

In three moderately severe cases of rheumatoid arthritis and in one serious case of ankylosing spondylitis the result was favourable. In two cases of rheumatoid arthritis with a complication (psoriasis, albuminuria) the improvement was temporary and relapse occurred in spite of a repetition of the initial high dosage.

The condition of the four favourable cases was maintained with 6×2 mg. of A.C.T.H. daily. A dosage of only 6×1 mg. daily resulted in a relapse in three of them.

An attempt was made to maintain their improved condition with gold therapy. More experience with this combined treatment is required before conclusions can be drawn.

The commonly known untoward reactions were observed in a varying degree. One patient developed a serious diabetes and also showed symptoms of vascular occlusion. These phenomena gradually disappeared with a low dosage or after discontinuation of the A.C.T.H.

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BURNS—I. INITIAL TREATMENT, LOCAL AND GENERAL*

BY

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A very considerable number of articles have been written on this subject during the last 10 years. The purpose of this paper is not to present anything new, but to emphasize certain points which, while often neglected, are essential if the objects of treatment are to be achieved. In brief, these objects are to restore the patient to his or her normal mode of living in the shortest possible time and with the minimum loss of function and disfigurement.

Success in these aims will be greater in those hospitals where there exists a plan of treatment from admission to discharge—a plan understood and adopted by all concerned. Experience may be a great teacher, but the registrars and house-surgeons, who so often play a major part in these cases, should from the outset have available the experience of their seniors; otherwise their bitterness will be as nothing compared with that of the patient.

Prevention and First Aid

Between wars, burns continue to occur with depressing frequency (Colebrook, 1950); depressing because so many could be avoided by common-sense methods. Fireguards should be essential, and not luxuries, wherever there are children or known cases of epilepsy in the household. The shining red element of an electric fire is an object of attraction to a child—an object to be grasped by the exploring hand with possible crippling consequences, and yet so easily avoided if the fire is fixed high up on the wall of the room. Tea-pots, tea-cups, and cooking utensils should be placed out of reach of a child's hand.

Immediately after the injury the patient will be suffering from shock of nervous origin—that is, akin to fainting. For this condition the treatment consists in keeping the patient warm (not hot), giving sweet drinks, and imparting calm reassurance. The use of narcotics will depend upon the presence of a doctor and the absence of any other undiagnosed injury.

The burned areas should be covered with the cleanest material available at the site of the accident, varying from sterile gauze in factory dressing stations to the cleanest linen material in the home, kept in position by firm but not tight bandages. Blisters should not be punctured. Clothing should not be removed unless there is a considerable delay before a hospital can be reached.

Burns Units

The Burns Unit of the Birmingham Accident Hospital, designed and planned with such magnificent results by Bourdillon and Colebrook (1946), is something to envy. With the present financial state of the National Health Service it is unlikely that other cities will be so fortunate. A compromise, representing a very definite step in the right direction, was reached by Professor Kilner during the war: it involved the sacrifice of a corner of the ward by converting it into a completely enclosed dressing-room. The expense involved is small and the beds are reduced by only one. Burns should not be dressed in the general ward.

*Read in opening a discussion in the Section of Surgery at the Annual Meeting of the British Medical Association, Liverpool, 1950.

Cleansing and Anaesthesia

The aim of the cleansing is to eliminate any bacteria on the burnt surface and on a considerable area of adjacent unharmed skin. Most authorities are agreed that the best agent for this purpose is a 1% solution of "cetavlon" (cetrimide, B.P.C.), which is both detergent and bactericidal. Gentleness must be the theme; the areas must be washed, not rubbed or scrubbed. Rubbing or scrubbing cannot do any good, and may easily damage or destroy unburnt layers in a case of partial thickness loss. The procedure should be regarded as a major operation, with all the usual preparation of personnel, but opinion is divided on the question of a general anaesthetic. Some prefer to rely on an analgesic with a dosage table covering all ages (Wallace, 1948), whilst others, including myself, employ a "light" general, using gas and oxygen supplemented if required with a little cyclopropane. Cyclopropane has the advantage of being comparatively non-toxic and capable of administration with large percentages of oxygen (Gray, 1946—personal communication).

Initial Dressings

The dressing is planned not as a mere cover, but with two distinct objectives. The first is to reduce the risk of infection and cross-infection so far as is possible—a risk to be borne in mind from the beginning to the end of the treatment. After seven years' experience, I still prefer the Bunyan-Stannard envelope method, full details of which have appeared in the literature (Bunyan, 1941; Hudson, 1941; Osborne, 1944). Alternatively, I would recommend either the use of vaselined gauze (Allen and Koch, 1942) or penicillin cream 400 units to the gramme (Clark *et al.*, 1943; Colebrook, 1950), with the local application extending beyond the burn, and wool and crêpe bandage well beyond the gauze. The bandages should be fixed by strapping which extends on to unburnt skin, or, especially in children, by a light plaster shell (Colebrook *et al.*, 1947), the aim being to prevent their becoming loose by movement or the exploring hands of the child.

The second object is to reduce the oozing and oedema due to the escape of plasma contents from the capillaries into the surrounding tissues. Unless resorption takes place within a few days the plasma becomes converted into a gel, followed by the proliferation of fibroblasts with subsequent fibrosis. To overcome this complication the use of pressure is implied (Allen and Koch, 1942). The pressure supplied by a dressing is neither a measurable nor a constant quantity; what is required is firm but not tight bandaging over a moderately bulky dressing or over the Stannard envelope. Such dressings should include the whole of the limb so as to avoid constriction with further oedema distally.

Plaster-of-Paris has been advocated on very sound principles (Barnes, 1943), but tragedies in the form of gangrene have been seen when such a dressing has been applied by the unskilled. The best and only constant pressure is the atmospheric. Elevation is thus indicated. Limbs should be elevated by suspension (arm with the hand splinted in position of function to a saline stand, leg with foot and back splint to a Balkan beam) and not by resting upon a heap of pillows. The elevation begins the moment the patient returns to the ward, and is maintained for 72 hours. Thereafter the limb is lowered for gradually increasing periods according to the initial severity.

Change of Dressing

Subsequent dressing of burns should be carried out with the same care and asepsis as at the initial dressing: it should therefore not be performed in the general ward.

Equally important is it that the patient's confidence should not be lost: there must be neither tears nor fears.

When an envelope is used, daily irrigations can be begun on the fourth day. Other types of dressing can be left until the tenth to the fourteenth day unless, (a) they have worked loose or been disturbed; (b) there is a staining of the bandages due to discharge from beneath—for in the presence of this there is an excellent track for the entry of organisms; (c) there is a persistent elevation of temperature not otherwise explained; or (d) if β -haemolytic streptococci are found in the smears taken at the initial cleansing. The majority of the partial-thickness burns will have healed during this period; on those that have not, the initial type of dressing should be renewed for a further four or five days.

Full-thickness Skin Burns

When the initial dressing is changed on the tenth to the fourteenth day the slough of a full-thickness skin burn should be starting to separate. Since the object of treatment should be to carry out skin-grafting as soon as possible, the aim must be to hasten separation of the slough. Clearly, surgical excision is the most rapid method, and when possible this should be done, but only if the surgeon is prepared to apply skin grafts two or three days later. If he is not so prepared, then the case should be transferred to a department where this can be done. Otherwise a totally unnecessary drain is placed on the patient's reserves, infection is inevitable, and scar contracture unavoidable, even if grafts are eventually applied. In small burns, especially industrial or electrical, it is possible to excise the burned area within a day or two after the injury. In the larger burns, however, the general condition of the patient generally makes it unwise to excise until the second week. That the excision is complete will be evident when bleeding tissue is reached, and it is this bleeding which often prevents immediate application of skin grafts.

If surgical excision is not carried out the type of dressing should be changed on the tenth to the fourteenth day. Instead of the initial penicillin cream, a chlorine-containing compound, such as eusol, Dakin's solution, or "milton," should be used in the form of compresses over tulle gras changed every 24 or 48 hours. It is at this stage that the Bunyan envelope method is most valuable, for by it the risk of added infection associated with frequent changes of dressing is reduced to a minimum. Furthermore, such dressings can be associated with pain, especially in children. There are two other methods of hastening the separation of sloughs—the first being saline baths, used with such success by Sir Archibald McIndoe (1940) during the last war. A continuous flow of saline, at a thermostatically controlled warm temperature, runs through the bath, into which the patient is placed by trained orderlies. The burns are thoroughly irrigated by the saline, and the patient experiences great comfort.

There is finally the use of such agents as pyruvic or phosphoric acid (Connor and Harvey, 1946) as primary local applications to the burned surface, changed every two or three days. This is said to lead to the complete separation of the slough in 10 to 12 days without damage to the underlying tissue. Enough is not yet known of the method in this country to pass any comment, but answers to inquiries made during a visit to America suggested that it is not without pain.

To summarize, in dealing with a full-thickness skin burn the aim should be to graft as soon as possible, preferably after surgical excision, but, failing this, immediately flat, red, firm, healthy (that is, no haemolytic streptococci present) granulation tissue is present.

FIG. 1.

FIG. 2.

FIGS. 1 and 2.—Condition of child aged 4 with full-thickness burns involving 30% of body surface. (November 23, 1949.)

Illustrative Case

A child aged 4, whose clothing caught fire on October 28, 1949, was taken to a local hospital, where the burns were dressed with sulphathiazole cream. She was transferred to the Plastic Surgery Unit, Stoke Mandeville Hospital, Aylesbury, on November 23, with extensive full-thickness burns involving 30% of the body surface. All areas were freely discharging pus (*Bact. coli*, *Proteus*, and *Ps. pyocyanea*). The dressings were foul-smelling and contained a large number of maggots. She had a swinging temperature (103° F.—39.4° C.). Haemoglobin 67%. (Figs. 1 and 2.)

The child was treated in a Bunyan-Stannard bed with irrigations of 1% milton. Autogenous postage-stamp grafts to abdomen, chest, and neck, taken from left thigh and lower leg, were applied on November 28. Post-operative dressing by

FIG. 3.—Postage-stamp grafts applied to right arm, back, and chin. (December 20.)

irrigation on December 1 showed 100% "take" of grafts. Haemoglobin 44%.

On December 20, postage-stamp grafts taken from left upper arm and left thigh were applied to right arm, back, and chin. Haemoglobin 75% (Fig. 3). First dressing on December 26 showed 100% "take" except in chin, where there was some loss.

Healing was complete by January 1, 1950, except for small areas on right thigh, to which further grafts were applied. Haemoglobin 86%.

In February, contracture of the neck, axilla, and right elbow scars was already marked, but the child was quite well and running about the ward (Fig. 4).

On April 18 the scar tissue of the neck was excised, followed by the application of a large free graft from the left thigh. Haemoglobin 82%.

This graft was dressed on April 24, showing a 100% "take."

Since then the child has been in a convalescent home, and will be readmitted for correction of the scar contracture of the axilla and elbow (Fig. 5).

FIG. 4.—Condition of child in February, 1950.

General Measures

On admission to hospital, save in minor injuries, there will be evidence of shock in the form of pallor, thirst, restlessness, and a rapid pulse. A fall of blood pressure is, however, a late sign in burns. Local treatment should not be started until there has been a good response to the treatment of the shock. This treatment is begun immediately, and consists in allowing the patient to drink freely of sweetened drinks, and in relieving pain, administering plasma, and applying warmth.

In regard to the last, the temperature should not exceed 70° F. (21.1° C.); there is often a tendency to apply heat rather than warmth, in the form of electric blankets or lamp-bearing cradles. Below, the general measures are discussed under the following headings: the circulatory system, metabolism, and infection.

The Circulatory System

As a result of the burn many of the capillaries and small vessels in the involved area will be destroyed or their contents thrombosed. In the underlying tissue, and in a wide adjacent area, the capillaries show an increase in the permeability of their walls, so that there is an outpouring of plasma. The local effect of this is blister formation or oedema, or both; the general effect is the manifestation of true shock. Since this plasma loss can be very considerable,

FIG. 5.—Condition of child after stay in convalescent home. Correction of scar contracture of axilla and elbow still to be carried out.

there is haemo-concentration, proved and measured by a haematocrit reading.

The loss of fluid may continue for as long as 72 hours with little absorption by lymphatics, and unless steps are taken to limit this loss the effects may be disastrous. If incorrectly treated, clotting of the escaped fluid occurs, with consequent limitation of movement, stretching of surrounding healthy tissue, with anoxia, and, finally, proliferation of fibroblasts followed by scar contracture (Glenn, 1944).

It is thus one of the most important problems in the early treatment of burns to find and use methods to control this abnormal loss from the capillaries. The measures at our disposal are: firm dressings, elevation (that is, the use of atmospheric pressure), immobilization, and intravenous administration of plasma or other fluid. The first three have already been discussed.

Plasma Loss

As plasma has been and is being lost the rational remedy is to give plasma by the intravenous route. It is safer to have some method of calculating how much plasma to give: no good can follow rapid infusions in large quantities. A rough guide

is that suggested by Harkins *et al.* (1942), giving 50 ml. for every 1% surface area involved. A more reliable method is the haematocrit. The first two pints (1.14 litres) can be given rapidly, but thereafter the rate should be 40 drops a minute. After the initial haematocrit reading (on admission of the patient) the amount to be given will be governed by further readings taken every few hours. The desired level is 45, but even when this is reached infusion should be continued for 12 to 24 hours, since the loss from the capillaries continues.

Anaemia

With a full-thickness skin burn involving 8% or more of the body surface anaemia will occur. The exact cause is unknown, but there is a depression of bone-marrow activity, and it is thought that infection and protein deficiency play a large part, certainly after the first week. If allowed to develop or remain untreated the consequences are (Moore *et al.*, 1946): a lowered resistance to infection (thus creating a vicious circle); anorexia; hypoproteinaemia; delay of application of skin grafts due to unhealthy granulation tissue; and reduction in the amount of take of skin grafts.

In view of these serious consequences it is clear that blood must be given early—even from the beginning of

treatment in severe cases—and repeated at intervals to maintain a high level of haemoglobin (80% or more). This demands estimations of the haemoglobin every two or three days, and in calculating dosage it is to be remembered that one pint (570 ml.) of blood will raise the level by 7%. One pint of packed red cells, which takes about six hours to run in, will raise the level by 12% (Le Hane, 1950—personal communication). Transfusions may be required as often as twice a week in extensive burns.

Metabolism

A great deal of work has been carried out on the changes in the chemistry of the blood and urine in cases of burns. These are complex and their aetiology not yet fully understood, but the outstanding feature is the disturbance of the metabolism of protein. In severe burns there is an increase over the normal requirement of proteins, because of the demand for tissue repair and the production of red blood cells. From the onset, however, there is a loss of protein due to plasma loss (exudation and oedema), followed by that due to toxæmia, discharge of pus, loss of appetite, haemorrhage (for example, graft-cutting or secondary haemorrhage), and a negative nitrogen balance. The plasma protein level (6.5–8.5 g. per 100 ml., with albumin/globulin ratio 1.7:1) may not fall at once while the patient's reserves (muscles) of protein are being used. There will, however, be the clinical signs of wasting and exudation from the burnt surface. Protein will be lost by exudation until skin grafts have taken and coalesced.

The consequences of hypoproteinaemia are an increased nitrogen loss in the urine, general malnutrition, oedema, and delay of healing. As protein is essential for repair and energy, its loss must be anticipated. It is easy to order a high-protein diet (for example, milk, especially skimmed, meat, liver, eggs, brewers' yeast), but unfortunately anorexia is a complication of burns.

Plasma is a poor, and blood a good, source of protein, but they are insufficient. The continued efforts of a good ward sister are required, but these may need to be supplemented by amino-acids given by means of a Ryle's tube. The fluid (for example, "casydrol") should be run in slowly and shut off at intervals, in order to diminish the nausea which is apt to follow. While such diet is essential if healing is to occur, and indeed if life is to be saved, it must not consist solely of protein; carbohydrate and sodium chloride are to be included (for example, glucose-saline drinks or infusions), together with a small amount of vitamin C (fresh fruit, vegetables).

There is therefore a need to keep an accurate intake and output chart, so that the surgeon and ward sister are alert to the day-to-day requirements. If the patient is making progress there will be a good output of urine of low specific gravity; on the other hand, oliguria with a raised specific gravity is a bad sign. The fluid loss is not entirely by the kidneys; there may be very considerable loss due to exudation and sweating. But the kidneys play the major part in eliminating the unwanted products of tissue breakdown, and the fluid intake must be sufficient to ensure a satisfactory output (for example, aged 6 months, 350 ml.; 2 years, 500 ml.; 10 years, 1,000 ml.; adults, 1,500 ml. a day).

Infection

A chart to record the results of all smears, suggested by Professor Kilner, saves endless trouble in looking through sheafs of reports. It also presents at a glance a picture of progress made and of the introduction of added infection.

Although the area burned is rendered sterile at the time of injury, it is only a matter of hours before bacterial contamination occurs. The aim of the initial cleansing is to render the burned area and the skin around for a considerable distance as bacteriologically clean as possible. The next aim is to maintain this cleanliness, which is achieved either by the use of occlusive dressings (envelope method) or by infrequent changes of dressings (Allen and Koch, 1942; Colebrook *et al.*, 1947) carried out under strict aseptic conditions. Under such treatment infection should not occur in the partial-skin-thickness burn. The only certain method of avoiding infection of the full-skin-thickness burn is immediate excision and grafting. When this is impracticable, bacterial contamination is to be expected when the slough is separating, and until grafts have coalesced. Provided the haemolytic streptococcus is not present and the number of other bacteria (staphylococci, diphtheroids, Gram-negative bacilli) is small, no serious consequence will ensue. Nevertheless, every effort must be made to keep this contamination to a minimum, and, if the haemolytic streptococcus appears, the explanation of how it got there must be sought at once.

Sources of Infection.—The possible origins of the initial bacterial contamination are: the application of unsterile coverings as first-aid measures—for example, rugs, blankets, etc.; the patient's own clothing before it is removed; and the nose, throat, and hands of those who inspect or dress the burn. The sources of origin of added infection (Colebrook *et al.*, 1947) are: the patient's nose, throat, skin, or alimentary tract (that is, in perineal or buttock burns); air-borne infection in the ward as a result of bed-making, changing dressings, or dusting of floors; interference with dressings by the patient, particularly children; from flies; from non-sterilized blankets, woollen jackets, and dolls; inefficient protective dressings; and faulty dressing technique.

Effects of Infection.—If infection is not kept under control sloughs are slow in separating, and pale, exuberant, dirty-looking (yellowish) granulation tissue will appear. Fever with an irregular temperature, anorexia, and anaemia will ensue, and so cause a delay in healing. The anaemia lowers the resistance to infection, and thus a vicious circle is established, which becomes increasingly difficult to break as the general condition deteriorates. The amount of discharge increases, with an unpleasant odour. The take of grafts becomes less certain as the amount of infection increases, and especially so if haemolytic streptococci are present.

Prevention of Infection.—Infection and added infection are prevented or kept to a minimum by intelligent first-aid methods, the administration of systemic penicillin from the moment of admission, scrupulous care at the initial cleansing, and the provision of a dressing (or envelope) extending well beyond the burned area, so applied that it cannot move (for example, slipping down a limb).

Thereafter the prevention of infection depends upon the maintenance of perfect cover; the acceptance of the principle that dressings shall not be carried out in the general ward; day-to-day inspection of dressings for any evidence of seepage of discharge; preventing interference with dressings by the fingers of young patients, by splinting of limbs; infrequent changes of dressing; taking smears for bacteriological examination at every change of dressing together with penicillin- and streptomycin-sensitivity tests; preventing anaemia and keeping the patient in a good general condition; and, above all, the early removal of sloughs and early application of skin grafts.

Treatment of Infection

It is to be emphasized that an anaemic patient will make but a poor and temporary response to any form of chemotherapy. Penicillin should be used systemically from the time of admission of the patient (100,000 units eight-hourly) or "distaquine" (300,000 units once daily). Whether penicillin is continued or a change is made to streptomycin (8 g. in a three-day course) will depend upon the results of the bacteriological examinations and sensitivity tests. Penicillin powder or penicillin-sulphathiazole powder (5,000 units of penicillin in sulphathiazole powder) can be used locally as a spray, but these are inactivated if "milton" disinfectant is being employed.

The difficulty in treating infected burned surfaces lies in the fact that the Gram-negative bacilli (*Pseudomonas pyocyanea*, *Proteus*, and *Bact. coli*) tend to predominate. The search for an efficient antibiotic for these organisms continues, and in the meantime no drug used singly or in combination can be relied upon with any certainty. The success of any drug or the decision to change to another is decided by the improved local condition checked by the results of the bacteriological examinations.

We find milton disinfectant of great value in the treatment of these mixed infections of burns together with systemic penicillin or short courses of streptomycin. With some of the smaller heavily infected granulating surfaces we sometimes use streptomycin compresses (1 g. dissolved in 50 ml. of normal saline) over tulle gras, with firm bandaging for two or three days immediately before applying skin grafts. The compresses are renewed three or four times a day.

The best treatment of all is the application of skin grafts, but this demands the presence of flat, red, firm, healthy granulation tissue (or a recently excised area)—a state of affairs possible only with assiduous local and general treatment as outlined above. Dramatic improvement may follow the use of plasma, even more so the use of blood, but relapse soon occurs after either. The successful application of skin grafts is the only means by which improvement can be maintained; the drain on the patient's protein reserves ceases; the appetite improves and is maintained; there is an increase in weight; and the mental outlook becomes bright and cheerful, more especially as function returns. To achieve this end quickly demands recognition that all concerned shall regard the treatment of burns as a major concern calling for team-work with sustained vigilance. Everything that is done for the patient must have a reasoned explanation.

Too often the initial treatment of a severe burn is excellent, but is followed by a period of inactivity during which the patient is literally dependent upon his own resources, and during which he steadily goes downhill.

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