BURNS—II. SKIN COVER FOR FULL-THICKNESS SKIN LOSS*

BY

J. P. REIDY, F.R.C.S.

*Plastic Surgeon, Westminster Hospital and
Stoke Mandeville Hospital*

For the purpose of this paper it is considered that the burned area of the patient is ready for the application of skin. The patient has been treated as described in the paper by Mr. R. P. Osborne (page 1025) and the granulating areas have been rendered healthy, flat, and free from sloughs as near three weeks as possible from the date of injury. It is not necessary, in my opinion, that the granulations should be sterile, but it is necessary for success that the bacteria should be reduced from +++ content to + by the use of appropriate chemotherapy. The preparation of granulations for grafting argues the need for frequent smears to check the bacterial content and to indicate the appropriate chemotherapy. It is surprising how often one meets cases of burns treated indiscriminately with penicillin, etc., without even one smear being taken.

Object of Early Skin-grafting.—Early skin cover, even if at first only partial, reduces toxæmia and improves the general condition of the patient. Successful early skin cover gives early healing, reduces the formation of fibrous tissue, and permits restoration of function. In short, the earlier the healing the better is the chance of the return of normal function.

Autogenous Skin-grafting

Except in those cases of burns of 40% or more of the body surface, it is usually possible and best to use the patient's own skin. There is no place to-day for pinch grafts in the treatment of burns: the donor area is pitted and spoiled for future use. The Thiersch graft is more satisfactory in every way.

Under general anaesthesia the donor site—for example, the thigh or arm—is cleansed with a solution of "cetavlon" 1% and then with ether-meth, and draped with towels. Sheets of thin split-skin are cut, using a skin-grafting knife or a dermatome. My own preference is for a Humby knife, or a Marks-Blair knife with a roller attachment. When sufficient graft is cut, the sheet of skin is spread, raw surface upwards, on tulle gras. This sheet is cut into strips $\frac{1}{2}$ in. (1.25 cm.) or less in width, and these strips, placed parallel to and close to each other on tulle gras, are again cut at right angles, so as to obtain small squares of graft $\frac{1}{2}$ in. or less across, arranged in chessboard pattern.

Skin graft applied as a sheet to a granulating wound is likely to fail because of the presence of exudate from the wound surface which creeps under the graft and lifts the whole sheet. The same sheet of skin graft applied as small squares is more successful in that exudate can escape between the squares and is absorbed into the dressing (Fig. 1). Furthermore, applied in squares, a given sheet of skin will cover a wound area larger than the original intact sheet. It is therefore more economical as well as more sure. As the epithelization occurs from the margins of the squares, the smaller the squares the greater the available length of margin. Although a "patchwork" appearance may result from the application of skin in this

FIG. 1.—Recent burns; face and eyelids. (a) Central tarsorrhaphy to right eyelids. Postage-stamp grafts to granulations. Slough still present on forehead. (b) Postage-stamp grafts coalesced. Thiersch graft to both right eyelids. (c) Months later: postage-stamp grafts replaced by sheet of Thiersch graft, to improve appearance. (d) End result. Hairy Wolfe graft to replace right eyebrow. Right eyelids separated.

fashion it must be stressed that the appearance is of secondary importance to the early healing and return of function.

The burned area is now exposed and a smear taken for bacteriological check. The granulations may be gently cleansed with "cetavlon" and then with saline, and finally compressed with dry gauze. There is no need to shave down the granulations, though this is advocated by some. The sheet of graft is applied to the granulations and held in place by strips of 3-in. or 6-in. (7.5-cm. or 15-cm.) cotton bandage stuck on to the normal skin adjacent to the burn area by "mastisol." Pressure is then applied, using gauze packs wrung out in normal saline and "elastoplast" or a many-tailed bandage.

Dressings are removed on the fourth, sixth, and eighth days after grafting only as far as the stuck-down cotton bandage, which is left undisturbed, so that the underlying grafts are not moved. Removal of dressings must be done very carefully, otherwise the grafts will come off as well. Smears can be taken of any exudate which escapes between the graft squares through the bandage on to the dressing. On the tenth day the grafts are exposed by the removal of the cotton bandage and tulle gras. The take of grafts is noted and the grafts are then re-covered with tulle gras and a saline gauze pack. Dressings thereafter are infrequent—every three to four days until the grafts coalesce, about 14 to 18 days after application.

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After this, return of function is encouraged by exercises, but it is not advisable to apply grease massage to the grafts until they are more consolidated—for example, three to four weeks after grafting.

Homogenous Skin-grafting

Contrary to reports, I do not believe that a successful take of skin from one person to another is possible. Medawar has shown in his experiments that such a take does not occur and that homogenous grafts are shed after three to six weeks. Homogenous skin is applied only in sheets, because in patches this skin promotes heavy formation of antibodies.

However, there are cases in which homogenous skin-grafting serves a purpose, albeit temporarily. Consider a child with widespread burns of 40% or more body surface. The trunk, thighs, and legs may be involved so that there is little or no unburned skin to provide grafts. Such a child will be gravely ill with toxæmia, anaemia, and fluid loss even when the sloughs have been removed or encouraged to separate. Provided the child survived, spontaneous healing would occur over many months, producing thin unstable epithelium over broad areas, with dense thick scarring in the flexures, which in turn would produce contractures, deformities, and loss of function. The early application of skin in sheets from another person would provide the "best dressing" for the burn areas, after separation of sloughs. It would reduce the toxæmia and tide the child over a critical period of three to six weeks. During this time some of the less badly burned areas would have time to heal and thus provide the patient with his own skin for grafting, if only a little at a time, until full skin cover was attained. Such temporary homogenous skin cover would qualify as a life-saving measure.

Splinting.—Areas that have been skin-grafted should be immobilized. Plaster-of-Paris gutters are most satisfactory to immobilize joints above and below the lesion.

Donor Sites.—Where possible, thighs and upper arms are chosen first. It must be stressed that as much skin as is necessary and possible should be taken from one limb before going on to another. For example, use one thigh to its utmost and keep the other thigh untouched in reserve to provide definitive skin cover. A donor site once used to provide Thiersch grafts can be used again four to six weeks later.

Application of Skin Grafts

Priority Areas.—Full-thickness skin loss of trunk and parts of limbs between joints is straightforward in that skin cover is the only issue. However, in those cases of widespread burns involving face and hands, in addition to other areas, there is a need to consider covering certain areas before others, particularly if there is likely to be shortage of available skin (Fig. 2). For example, ectropion of the eyelids should be dealt with first, in order to allow the lids normally to cover the cornea. Finger-joints and limb flexures come next in importance, and, finally, broad areas, such as trunk, thighs, forehead, cheeks, and lips. The burned hand at all times must be placed in the position of function (grasping a tennis-ball)—the best position for ankylosis, should ankylosis occur. This position is main-

FIG. 2.—Recent burns; face. (a, b) Appearance in toxæmia. Ectropion of all eyelids; loss of nose-tip and parts of ears; loss of skin of forehead and cheek; (c, d) End result. Treatment prolonged, with intervals out of hospital. Postage-stamp grafts to forehead and cheeks still remain. Thiersch grafts to eyelids and lips. Hairy Wolfe grafts to eyebrows. Left upper arm flap to nose. Small tubed flaps from neck to margins of pinnae.

tained by splinting while skin grafts are being applied and until they have taken.

Full-thickness Skin Grafts and Skin Flaps.—There is no indication, in my opinion, for the use of Wolfe grafts or skin flaps in the primary skin cover of burns. A Wolfe graft is a free graft of whole skin thickness. This leaves a defect which usually requires a Thiersch graft to cover it. Furthermore, a Wolfe graft is a more difficult graft to handle successfully than a Thiersch graft even under ideal conditions, and from a practical viewpoint it is not good surgery to put a Wolfe graft on to a granulating area in a burned patient and to hope for success. The use of skin flaps is best left to a later date, when healing and restoration of function have been obtained by using Thiersch grafts as described earlier.

Causes of Failure of Skin Cover in Burns.—(1) The application of a sheet of skin graft to a granulating area has less chance of success than covering with "postage stamps." (2) Placing grafts on unhealthy or too heavily infected granulations will lead to loss of some or all the grafts. The *β*-haemolytic streptococcus and *Pseudomonas pyocyanea* are potent sources of failure when present in heavy concentration. Adequate pre-operative pressure dressings on the granulations, with antiseptics or the appropriate chemotherapy, are necessary to obtain flat healthy granulations. (3) Imperfect pressure dressings to the grafts and incomplete fixation of the dressing will allow movement of the dressing on the graft and the collection of exudate under and around the grafts, with failure. Absent and poor splinting to the grafted limb may produce the same unsatisfactory results. (4) Rough removal of dressings on the fourth, sixth, and eighth days—that is, by tearing off grafts which had in fact taken. (5) Poor general condition of the burned patient will lead to partial or total failure of grafts. Mr. R. P. Osborne in his paper has indicated general and local preparation of the burned patient.

Methods of Cutting Skin Grafts.—

There are various knives in use. To obtain small grafts the ordinary cut-throat razor may serve. On the other hand, those in frequent practice prefer the Blair knife, the Humby and Marks-Blair knives, which have an adjustable roller along the edge of the blade, or the dermatome. The various knives are most suitable on plane surfaces—for example, the sides of the thighs—but on the abdomen or back suction boxes are usually required, to produce a plane surface. The dermatome can be used on any surface, as the sticky drum picks up the skin and presents it to the knife edge. Knives and drums have their separate followers.

Refrigeration of Grafts.—

Sheets of skin wrapped in tulle gras and placed in sealed sterile bottles in an ordinary refrigerator can be preserved for several weeks and then successfully used. This has been described by Jerome Webster (1944) and by D. N. Matthews (1945). The procedure is particularly effective in the treatment of moderately burned children, in that when the first cleansing of the burned area is undertaken under anaesthesia the grafts can be cut and refrigerated, to be used during the succeeding two to three weeks as the granulating areas permit, without the necessity of further anaesthetics. Combined with envelope therapy, the number of anaesthetics for a particular case can be reduced to two or even one.

A point is now reached in the treatment of the burned patient where, following the application of skin in squares, early healing is a fact. Consistent with the extent of the burn, the earlier the healing, the better the chance of return of function. The physiotherapist comes into the picture about three weeks from the date of grafting, with appropriate exercises to the limbs, gentle grease massage, and wax baths to the grafts.

Sequelae

Despite all this, certain sequelae may and do arise: (1) irritation in and around the grafts; (2) contractures; (3) keloid scarring.

Irritation in and Around the Grafts.—This is often relieved by antihistamine drugs internally and calamine lotion and antihistamine creams locally.

Contractures.—Particularly in the flexures, there may arise bands of scar tissue limiting joint movements. There may be some response to grease massage and to night-splinting, but marked degrees of contracture are on occasion inevitable. In these cases the only immediate consolation is that without skin-grafting it would have been much worse. Reference will be made to such cases later.

Keloid Scarring

Quite apart from burns, many people develop keloid scars where the skin has been traumatized. Frequently keloid will occur in the area between the mouth and lower neck, and also on the front of the chest, and yet not

FIG. 3.—Old burns; face, neck, chest, axillae; keloid scarring. (a, b, c) On admission, scar contracture of neck and axillae; dense keloid. X-ray therapy. (d, e, f) After transfer of abdominal tubed flaps to neck in stages. Recurrence of keloid scarring.

elsewhere (Fig. 3). On the other hand, some few patients show marked keloid everywhere on the body. In those cases in which keloid occurs it has followed suture of a skin wound under tension. It is a frequent complication in burned patients, and in my experience appears about one to two months after healing. The keloid scars may continue to increase for several months, and then show fading over a period of years.

Recent and rapid keloid formation is red, raised, hot and tender on pressure, and irritates to a marked degree. Old and slowly forming keloid scarring is hard and pale. Keloid scars and hypertrophic scars differ histologically only in the accumulation of scar tissue. Keloid scarring will recur after excision of a keloid scar and suture, at the margins of skin grafts and flaps, and in the donor site of a skin graft. There is no known cause for the occurrence and recurrence of keloid scars, and there is no consistent difference histologically between keloid scars, hypertrophic scars, and ordinary scar tissue. The tendency to keloid scar formation in a patient is said to diminish after the early twenties.

It is a practical point to review all cases of recently healed burns one to two months after healing, in order to check the occurrence of keloid.

Treatment of keloid scarring is sought, therefore, for pain, irritation, deformity, and disfigurement. Pain and irritation in the early keloid are treated by moderate doses of x rays or radium, and relief occurs over two to three months. The irradiation must be superficial and limited to the skin area involved. The dosage is that which produces a faint erythematous reaction in the skin, and this is a matter for the judgment of the skilled radiotherapist. X rays or surface radium may be used, and where low-voltage therapy apparatus is available the technical superiority of x rays over radium is unquestionable.

The keloid scar becomes softer and paler and less indurated during several months after irradiation, and this regression may proceed for one to two years and so reduce any disfigurement. Where there is deformity by contracture, release of the contracture and the insertion of a skin graft is usually necessary, associated with pre-operative and post-operative irradiation.

The recent red fleshy scars respond best to irradiation. The whiter and older keloids are usually hard and fibrous, and these respond less well to radiotherapy, though it is advisable to combine radiation before and after excision. The same procedure is indicated in the surgical excision of keloid linear scars—to enlist the help of the radiotherapist. Linear scars are usually given irradiation five to ten days before operation, so that excision takes place during the actual period of x-ray reaction. Post-operative irradiation takes place shortly after the removal of stitches—that is, five to seven days after excision of the scar.

Late Cases of Burns and Healed Burns

Naturally, not all cases of burns reach the plastic surgeon in the early stages; nor is this desirable—otherwise he would be overwhelmed. Some cases arrive partly healed, with granulating surfaces and early contractures, and some are healed, but with scar contractures, loss of function, and disfigurements.

The unhealed cases are treated as primary cases, with investigation of the general condition, as well as provision of early skin cover. It is equally important to consider the levels of blood, plasma proteins, salts, and vitamins in these as in the early cases.

The healed cases include all those, of whatever source, in which there is loss of function and/or disfigurement by scarring. These may well be present even where adequate preliminary patch grafts have been applied, but it is expected to be less where this early treatment has been available.

The problems here are long-term and consist of: (a) restoration of function by scar excision and suture, scar excision and skin-grafting, and attention to tendons and joints; (b) improvement of appearance by irradiation of keloid scars, the use of full-thickness (Wolfe) skin grafts, and the use of skin flaps; and (c) physiotherapy, occupational therapy, and rehabilitation, as treatment of these cases may be spread over several months with intervals out of hospital.

Restoration of Function.—In brief, attempts are made to free affected joints by removal of scars, with or without the insertion of skin, and by the employment of the Z-plasty procedure. Attention to tendons and joints may require sheet skin or flaps on the backs of the hands and digits, and stripping up of extensor tendons to allow freedom of movement. Capsular thickenings, particularly around the metacarpophalangeal joints, can be relieved by capsulotomy. The position of ankylosed interphalangeal joints may be improved by arthrodesis, and, in fact, arthrodesis may be indicated where work on tendons is not justified by the expected result. Amputation of the fifth finger in a badly burn-scarred hand is often necessary.

Improvement of Appearance.—X-ray irradiation of keloid scarring of the chin and cheeks may improve the appearance sufficiently to do without surgical treatment. The use of full-thickness skin (Wolfe) is reserved for the purpose of obtaining good cosmetic results—for example, the provision of hairy grafts for eyebrows, and to provide skin for eyelids, nose, and cheeks of good colour and texture. Skin flaps are used in burn cases to provide skin and subcutaneous tissue where these have been lost—for example,

on the face and neck, and on hands. The area to be covered should be known when the flap is raised, and for this reason the skin flap is used for final cosmetic results, after function has been restored so far as is possible, and not to release a scar contracture where the extent of gape of the incised wound cannot be predetermined.

Physiotherapy.—At all operative stages the surgical treatment is backed up by the physiotherapy department, members of which do so much to restore the usefulness of limbs and joint muscles, and to improve the blood supply of grafts and flaps. Further assistance is gained from occupational therapy between operations, to relieve boredom, as well as to improve function. This includes weaving, knitting, leather work, carpentry, and machining, though these are particularly applicable to hand injuries. Extremely useful progress has been made by certain firms in the motor industry who have modified their machine tools to assist the worker with joint and tendon injuries.

BIBLIOGRAPHY

- Allen, H. S. (1948). *Surg. Clin. N. Amer.*, **28**, 125.
 — and Koch, S. L. (1942). *Surg. Gynec. Obstet.*, **74**, 914.
 Block, M. A., and Tsuzuki, M. (1948). *Amer. J. Surg.*, **75**, 417.
 Braithwaite, F., and Moore, F. T. (1948). *Brit. J. plast. Surg.*, **1**, 81.
 — and Watson, J. (1949). *Ibid.*, **2**, 21.
 Brodie, N. (1947). *Amer. J. Surg.*, **74**, 834.
 Brown, J. B., and McDowell, F. (1943). *Skin Grafting of Burns*. Lippincott, Philadelphia.
 Bunyan, J. (1941). *Proc. R. Soc. Med.*, **34**, 65.
 Cope, O., Langohr, J. L., Moore, F. D., and Webster, R. C. (1947). *Ann. Surg.*, **125**, 1.
 Curtis, L. (1947). *Surg. Clin. N. Amer.*, **27**, 1466.
 Douglas, B. (1944). *Surgery*, **15**, 96.
 Farmer, A. W., and Woolhouse, F. M. (1945). *Ann. Surg.*, **122**, 39.
 Hannay, J. W. (1941). *British Medical Journal*, **2**, 46.
 McIndoe, A. H. (1941). *Proc. R. Soc. Med.*, **34**, 56.
 Matthews, D. N. (1945). *Lancet*, **1**, 775.
 Osborne, R. P. (1944). *Brit. J. Surg.*, **32**, 24.
 — (1945). *Postgrad. med. J.*, **21**, 121.
 Owens, Neal (1947). *Plast. reconstr. Surg.*, **2**, 226.
 Pearson, R. S. B., Lewis, E. E., and Niven, R. B. (1941). *British Medical Journal*, **2**, 41.
 Pfahler, G. E., and Keefer, G. P. (1948). *Amer. J. Roentgenol.*, **59**, 378.
 Reidy, J. P. (1944). *Proc. R. Soc. Med.*, **37**, 705.
 — (1948). *Med. Pr.*, **219**, 5.
 Ross, W. P. D. (1950). *Brit. J. plast. Surg.*, **2**, 233.
 Wakeley, C. P. G. (1941). *Proc. R. Soc. Med.*, **34**, 43.
 Wallace, A. B. (1949). *Brit. J. plast. Surg.*, **1**, 232.
 Watson, E. F., Hoge, W. G., and Koch, S. L. (1946). *Quart. Bull. Nthwest. Univ. med. Sch.*, **20**, 286.
 Webster, J. P. (1944). *Ann. Surg.*, **120**, 431.

In the annual report (1949) of the Colonial Office on the East Africa High Commission (H.M.S.O., London) reference is made to the establishment in Nairobi of the East African Bureau of Research in Medicine and Hygiene. The Filariasis Research Unit, with headquarters in Mwanza, Tanganyika Territory, was also set up in 1949. The objects of the unit are to ascertain how serious a problem filariasis is to the economy and welfare of East Africa, and to investigate methods of control and treatment of filarial diseases, either by the use of drugs or by the control of insect carriers, or both. Pilot surveys were carried out in Tanganyika, and the results showed that bancroftian filariasis was worst near large masses of water—salt and fresh—and confirmed the remarkable patchiness of distribution of the disease even in areas showing a high overall incidence. Hetrazan has been found very effective in abolishing larval forms of filariasis from the body surface. Different courses of treatment have been tried out, and the individuals concerned will be followed up to ascertain the relative merits of the different dosage schemes. The East African Medical Survey is continuing its work in spite of staffing difficulties. The aim of the survey is to obtain a picture of the state of health of the African and information about how best to control the more important of the common diseases of East Africa. An innovation which will prove of value is the introduction in the Malaya area of registration of births and deaths. In Kenya research is continuing on relapsing fever.