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Surgical considerations of the burn wound

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INTRODUCTION

Though burns are among man's most ancient enemies, we have yet to purge them to satisfaction. They are a worthy opponent to the best armed physician and frequently outwit even the greatest of strategists. Few other ailments represent so great a challenge to knowledge in anatomy, physiology, bio-chemistry, pathology, surgery, medicine, bacteriology, genetics and psychiatry, the armamentarium of the physician. It is not within the scope of this paper, therefore, to discuss the burn patient as a whole entity. I have taken the liberty to refresh the readers' mind with the basic pathology and physiology of the burn wound; with local treatment of the burn wound; and with complications arising at the site of the burn wound.

SURGICAL CONSIDERATIONS OF THE BURN WOUND

The oldest classification of burns correlated the surface appearances of the burn wound with the severity of injury. Erythema, vessication, crusting, and charring were the basis of the divisions. Later certain outward appearances became associated either with the pathological concepts of inflammation and necrosis, or the depth of the injury. Wiseman, in 1676, classified gunpowder burns into groups: (A) "Superficial, it raiseth the cuticle up into blisters", (B) "Deeper into the skin...it causeth an eschar", and (C) "Deeper into the flesh...it maketh a hard crust with a contraction". (1) The best known of the older classifications was that of Dupuytren in 1832, who divided burns into six numerical degrees largely according to depth but partly according to outward appearance. Unna, in 1896, strongly criticized surgeons for regarding "burns from their three most striking results, first, redness of the skin, second,formation of bullae, and lastly, the formation of scabs." "It has then tacitly been assumed that only eschar formation is accompanied by tissue necrosis, and that the fact that every form of burning induces necrosis is consequently overlooked." A simple erythema indicated rapid healing, and charring meant the absence of healing, while those in between were a matter of guesswork.

The severity of the burn wound may be assessed quite satisfactorily as it depends upon two principle factors; the percentage of the body surface damaged, and the depth of the tissue damaged. Other factors than these must be considered in the over all picture, however, the most important being age, general physical condition prior to burning, and concomittant ailments as cardiovascular disease, pulmonary, renal and systemic diseases. The problem of management then becomes increasingly difficult and chances of survival proportionately diminishes if these systemic diseases as well as mechanical injuries like fractures, lacerations, and head injuries are all present. (2)

Extent of a burn is usually expressed as a percentage of surface areas of the various parts of the body. The rule of nine formulated by Pulaski and Tinnison divides the body surface into areas of 9%; the head and neck 9%, anterior trunk 18%, posterior trunk 18%, each lower extremity 18%, each upper extremity 9%, and the perineum 1%. (3) This is without doubt the most widely used method but is lacking in accuracy of varying ages. Lund and Bronder determined the changes in percentage of the body surface of varying parts that occur during the different stages of development from infancy through childhood. (4) The following chart is from their original article. The numbers are percentage of areas.

Area	Birth-1 year	1-4 years	5-9 years	10-16 years	Adult
Head	19	17	13	11	7
Neck	2	2	2	2	2
Anterior trunk	13	13	13	13	13

Posterior trunk	13	13	13	13	13
Buttocks	5	5	5	5	5
Genitalia	1	1	1	1	1
Arms	14	14	14	14	14
Hands	5	5	5	5	5
Thighs	11	13	16	17	19
Legs	10	10	11	12	14
Feet	7	7	7	7	7

Depth of the burn wound is most commonly classified as first, second or third degree. The first degree burn involves only the outer layer of the epidermis and is characterized by erythema. Necrosis is confined of the epidermis and healing occurs readily with simple desquamation. Second degree burns are characterized by a presenting wet or blistered surface, and are red or pink. Destruction of the epidermis and the upper part of the dermis has occurred but sufficient epithelial elements remain in the dermis to allow epithelial resurfacing. Third degree burns vary from color of white to gray or may present a charred surface. Complete or virtually complete destruction of all dermal epithelium has occurred. Resurfacing by epidermis, if at all possible, can only take place by epithelialization from the normal epidermis at the wound edge. (5) This arbitrary division by degrees is, of course, an over simplification for purpose of communication. The most difficult differentiation lies between the deep second degree and third degree burns.

Knowledge of the etiology of the burn correlated with the above named mentioned points is often helpful in determining the degree of burn. Second degree burns are often the result of hot liquids or short flash type burns, contrasted to third degree burns usually caused by some type of flame. Often helpful in distinguishing between the two is the sensitivity of the wounded area, both objectively and subjectively. The acutely burned patient who is comfortable and complaining of little or no pain, with a wound having the appearance of a third degree burn may be considered as a probably third degree burn. A needle may be employed to map out areas of anesthesia, hypesthesia or hyperesthesia to aid in the differentiation. All nerve endings are destroyed in third degree burns, in contrast to partial loss with hypersensitive remaining fibers in second degree burns. (6) The burn is tested for sensitivity to pinprick with a sterile needle. About a dozen pricks to the square inch are necessary, partly because the pain spots are localized and partly because the whole skin area may be patchy. As in all subjective tests the patient must be cooperative and understand what is required of him; any pain on pricking indicates partial skin loss, while whole skin loss burns are always analgesic. However, analgesia may also be found in deep partial skin loss burns, particularly on the face, scalp, palms and soles of the feet. This is presumably because some of the sweat coils are situated deep to the deepest level of the pain nerve-endings in the skin and some in subcutaneous fat. In certain chemical burns the test is less reliable due to selective absorption through the skin of nerve toxic products, viz. the burn agent. (1)

The stratum corneum is often loosened into its component layers and this probably results from the expansion of keratin and its temporary transformation into a semiplastic material. Sometimes there is a horizontal gradation of changes in the epidermis extending for several millimeters at the edge of a burn, but often the zone of disintegration necrosis is small or absent and the junction between viable and heat coagulated epidermis is fairly sharp. Superficial burns may then be defined histologically as those in which the deeper part of the epidermis, particularly the basal cell layer, remains viable and is not irreversibly affected by disintegration necrosis or heat coagulation. Unlike the skin of most animals, human skin blisters readily, probably because the superficial capillary network of the dermis is highly developed and has intimate ramifications in the subepidermal papillae, while in animals the superficial plexus is less well developed. The blister fluid exudes from the superficial capillaries and collects below the epidermis because the cement membrane between the dermis and epidermis has been destroyed. Histologically, incipient blistering is manifest by small spaces containing an eosinophilic exudate between a few basal cells and the dermis and perhaps rupturing between basal cells and adjacent prickle cells. The epidermal roof of blisters is usually heat necrotic.

Sometimes the deep epidermal cells are viable in burns which result in epidermo-dermal loosening. Vessication would then produce secondary epidermal necrosis. In sections the blister fluid appears as an eosinophilic albuminous exudate containing numbers of polymorphs and often strands of fibrin. (7) It has been postulated that the cementing membrane disappears because it is digested by the uncontrolled activity of skin proteinace on its way from the heat injured epidermis to the dermis. (8) This is plausible because Medawar found that by treating slices of human skin with trypsin sharply separated the epidermis from the dermis, and he thought that this was due to digestion of the elastin. (2) The dermis is affected in all burns which produce primary heat necrosis of the whole epidermis, or vessication, the depth to which the dermis is involved and the quality of changes depend on the surface temperature and dessication of burning; in general the prolonged burns are deeper and the higher temperature burns produce necrosis. In many biopsies of the skin, the epidermis is absent, the dermal papillae are exposed and flattened, particularly in severe burns. They also show a vertical gradient of changes; the severest effects are near the surface, the deep dermis is least affected and the middle zones are intermediate in severity. The gradient of epithelial damage in partial skin loss burns affects the sheaths of hair follicles, the sebaceous glands and sweat glands. Few sweat coils are affected because they are deeply placed. The vertical gradient from the surface downward may be heat coagulation, heat disintegration, reversible cellular changes and normal epithelium. In addition to the histological signs of necrosis, other evidence of irreversibility are rupture of the fatty cells of the sebaceous glands, distortion of the hair sheaths, small rents and fissures in the epithelium of the follicles, and cytoplasmic eosinophilia. Heat coagulated nuclei are often elongated and distorted with indistinct outlines. Karyoloysis, karyorrhexis or pyknosis may be present. It may be difficult to decide whether the changes are reversible or likely to have progressed as disintegration necrosis. Repeated biopsy may be needed to determine this, depending, of course, on how soon after the burn the initial biopsy has been taken. In superficial burns, the vessels of the superficial capillary complex are particularly hyperemic. When congestion is seen, the capillary endothelium is swollen and the cells are loosened. Numbers of red cells may be seen free nearby having escaped by diapedis. Their breakdown to hemosiderin may contribute to the brown discoloration of recently healed superficial burns. Stagnation and staisis of the capillary may be difficult to distinguish histologically from those of congestion with excess polymorphs aligning themselves to the capillary wall. Characteristically many capillaries and venules are dilated, capillary loops are often elongated and are plugged tight with closely packed red cells. At first these retain their normal outlines, but later they may fuse, become necrotic and appear as eosinophilic pseudo-thrombi.

True thrombosis may follow and also affect larger veins. Edema increases the depth of the dermis but histologically is not always readily recognizable. Sequestration of the fibers of the erector pili muscles is due to edema and the collagen bundles may also be sequestrated. (2)

The treatment of the burn wound must necessarily begin with the first person to see it. This first care is vitally important, misguided zeal has frequently resulted in far greater damage than the original trauma inflicted. From the standpoint of the person giving first aid, the most important points are to relieve pain and anxiety and insure an adequate airway. In severe burns of first and second degree nature, the first aid treatment will spare the victim much suffering and make the work of the surgeon far easier. Ideally, the earlier the treatment begins, the better chance the burned individual has of recovering from his injury with the minimum of deformity. (9) Pain is relieved by medication adequate to control it. Very simple first degree burns of limited areas may have their discomfort controlled by the use of five to ten grains of aspirin orally. Codeine in .5 to 1 grain doses or codeine with aspirin is far more effective. Larger area burns of first and second degree nature, as well as minor burns,may be treated without medication simply by removal of clothing, bandages, salves and condiments covering the areas, and emersion of the member in cool water. The traditional treatment of burns among lay people in Iceland is immediate application of cold water for as long as the pain exists. Experiments with rats have shown benefit from similar treatment. Ice cold water seems to cause additional shock to scalded rats, but cool water reduces local pathologic changes and mortality and improves healing. Cool water therapy is far more effective than cooling air, which takes longer and requires elaborate apparatus unlikely to be at hand. (10)

Every effort should be aimed at minimizing further contamination and achieving a surgically clean wound. If some burned clothing adheres to the injured surface, it must be soaked off. All personnel who come in contact with the patient must be masked. The patient may then be taken to a clean dressing room or operating room where a strictly aseptic technique can be carried out. The temperature of the room should be about eighty degrees Fahrenheit, and currents of air should be avoided as they increase patient discomfort. The burned areas are cleansed thoroughly by use of non-alcoholic soaps, Septisol being a current commercial favorite in this area. (11) All debris and detached epidermis must be removed. Greases or ointments that may have been applied must be removed with soap. Tars and other oily preparations may be dissolved with benzene. The surrounding normal skin is shaved, and the area irrigated with sterile saline or water. (12) All blisters may be broken and the devitalized epithelium cut away. Some surgeons favor leaving unruptured blisters and blebs as they feel the epidermal covering provides a good dressing. (13) However, most blisters break before complete healing occurs, leaving devitalized tissue on the wound surface where it becomes excellent culture media. (14)

After the wound has been thoroughly cleansed and irrigated, the surgeon may then elect to care for the patient by the closed or open method, as dictated by the nature of the burn, experience, circumstances as to field unit or well staffed general hospital, and psychological evaluation of the patient and his family. The aim of a dressing is to cover the open wound by the best available means in order to protect it from the constant danger of infection. A good dressing does not fix or destroy any part of the skin remaining viable and provides for drainage of the serum. It should exert a uniform pressure, moderate in degree, and should be easily removable. The dressings should be applied in such a manner that the injured area is kept at rest. It was formerly believed that firm mechanical pressure would inhibit the amount of exudate that flowed from the wound thereby decreasing fluid loss. In the last few years it has been shown that this does not appreciably decrease fluid loss but merely shifts the collection of fluid to the interstitial spaces proximal to the wound. (15) Single layer strips of lightly impregnated vasoline fine mesh gauze are laid over the wound. These should never be quite long enough to encircle an extremity, as edema may then produce constriction. The gauze should be lightly impregnated, as heavy impregnations do not present an absorptive surface, and serve only to macerate the edges of epithelium. Nylon and other finely woven materials have been tried as an initial layer in hope that they would not stick to the surface. The disadvantage shown was that the minute interstices became filled with dried exudate and prevented the absorption of fluid from the wound surface. A moist surface is then maintained, with bacteria multiplying rapidly and abundant purulent exudate is then held onto the wound. The petrolatum should be smoothed out allowing no dead spaces, and a very absorptive bulky layer of fluffed gauze or mechanics waste placed next to the initial layer. The outer portion may then be formed by using several large absorptive abdominal pads. A final dressing is then placed to hold the bulk area, usually made of cotton elastic material, stockinette, or conforming type bandage. Great care must be taken in applying these dressings in order to produce even resilient compression without constriction. The time for subsequent dressing changes is predicated on the necessity for keeping the wound clean. In some partial thickness burns an adequate dressing may be left in place for ten days or longer, while in some deeper burns, it may be necessary every other day. Indications for changes are moist bandages, stained bandages, malodorous bandages, increased pain or unexplained increase in temperature. All dressing changes must of course be made under the strictest of aseptic conditions just as the original dressing was made. Moistening the bandage just prior to removal will usually facilitate matters, as well as gain the patient's confidence, as most changes will be made without benefit of anesthesia or analgesia.

Credit for the re-introduction of the exposure method is given to Wallace of Edinburgh. Blocker and Pulaski are generally credited for its re-introduction into the United States. Locally Wilson and Swenson have been the champions for exposure method treatment during the past decade. The accepted technique is much the same as mentioned above in discussion of the closed method. The patient is initially debrided and cleaned, but then placed in bed on clean non-sterile sheets in the most comfortable position that completely exposes the affected areas. The exudate of a partial thickness burn dries in forty-eight to seventy-two hours and forms a hard crust that serves as a natural protective cover for the wound. Epithelial regeneration proceeds beneath this crust and is usually complete in fourteen to twenty-one days. The crust then falls off spontaneously and leaves behind a non-scarred, healed surface. However, this is not the case in full thickness burns. Surface exudation is minimal, if present at all, and crust formation does not occur. Instead, the pearly-white or charred dead skin dehydrates and is converted into an eschar in forty-eight to seventy-two hours following exposure. This eschar then serves as a temporary physiologic cover until liquifaction occurs beneath it in twelve to twenty-one days. The term eschar refers to the dead tissue of a full-thickness burn, whereas the term crust should be reserved to designate the firm cover over an exposed partial-thickness burn which is composed principally of dried exudate. Once the burned surface is dry, all efforts must be directed toward avoiding injury to crusts and eschars. Cracks facilitate bacterial invasion and infection, and the protective covering surrounding these cracks becomes lifted from the underlying tissue and must be trimmed away. If these open areas are covered with a piece of moist fine mesh gauze, a new crust will form. If suppuration is spreading, crusts or eschars must be removed and dressings applied. The temperature and humidity of the environment have a direct effect on the time of formation of a crust or eschar, in that a dry environment hastens the formation. The crust over a superficial second degree burn desquamates in ten to twelve days, if there are no complications. In deep dermal burns, the crust tends to be thicker and adheres for twenty-one to thirty days. In third degree burns liquifaction begins after about twenty-one days, at which time softening of the eschar becomes palpable. The eschar is then ready for removal, as granulating tissue may then be seen beneath the softened eschar. As soon as it begins to loosen, the collaginous bands are cut and the area is completely debrided. At this time treatment by exposure ends, as granulating tissue should never be exposed. (12) In comparing these methods it must be emphasized that either the closed method or open method will give satisfactory results if properly employed. In deep burns the open method will usually give better results. Frequently it is necessary to employ both techniques to accomplish satisfactory results. Holman and associates found in controlled burns on animals, the ratio of epithelialization in the open method was one point eight to one. The average healing time was twenty-one days open method and thirty-nine days closed method. Recognized advantage of the closed method are: (A) Applicable to practically all areas; (B) Less nursing required in extensive burns, initailly; (C) Aids in transportation over long distances; (D) Minimizes the invitation to neglect that an open crusting burn wound offers; (E) Better immobilization of certain areas may be obtained. Disadvantages are: (A) Increase in infection complications; (B) Slower and more difficult ambulation leading to greater impairment of skeletal function; (C) More difficulties with fluid, plasma and blood requirements. Advantages of the open method are: (A) Fewer and less severe infections; (B) Less destruction of surrounding viable epithelium; (C) Earlier and easier ambulation; (D) Fewer electrolyte, plasma and blood problems; (E) It is readily adaptable to children. Disadvantages of the open method are: (A) Infection may develop under the crust and if neglected, may convert a second degree burn to a third degree burn; (B) Patients may be more uncomfortable; (C) More nursing care is required initially; (D) Circumferential eschars around fingers may cause eschemia by edema; (E) In removing the eschar viable epithelial elements may be lost; (F) Frequently, it is psychologically difficult for a patient or relatives to continually observe an open wound. Following sequestration of the crust, the patient may be considered for discharge with protective coverings for the very thin epithelium and directions for restriction of activity for a length of time commiserate with severity of initial injury. (6)

Third degree burn wounds must necessarily be grafted as epithelialization will not take place over distances greater than two centimeters. In general it may be stated that grafting should be carried out as early as possible. The prime advantage of early grafting in extensive burns is that the processes of wound healing are instituted prior to inevitable serious problems of nutrition and infection. Mans' discovery of grafting tissues has its roots in the far away past of prehistoric medicine. The ancient Peruvians covered the trephine opening with a gold plate, presumably to prevent a soft spot in the patient's skull that would be vulnerable to enemy's knife or axe and to serve as a barrier against the entrance of evil spirits. Primitive races in various parts of the world until quite recently used bone grafts to replace a bone destroyed by injury or disease. Preference was given to the bones of a freshly killed dog or sheep. An American physiologist named Guthrie performed the two-headed dog experiment in 1908 and succeeded in maintaining viability of the transplant for about two days, thus anticipating the celebrated Russian experiment by more than fifty years. (16) No discussion of the history of grafting would be complete without mention of Tagliacozzi, a seventeenth century Italian surgeon, who devised the pedicle grafting technique to replace noses lost in the popular sport of the day--rapier dueling. There are two basic forms of grafting, autografting and homografting. It is currently being taught in most medical schools that the autograft is the desired form, in that epithelium and organs of one's own body or that of an identical twin sibling are best used. However, if autografts are not available, then cadaver homografts or donor homografts may be employed. That homografts are destined to slough in most circumstances is also common knowledge. This is predicated on the antigen-antibody response theory, first advanced in this connection by Gibson and Medawar in 1943. They also introduced an important new concept in the fact that a recent crop of cutaneous homografts from the same donor to the same recipient disintegrate at a faster rate than does the first, owing to an actively acquired immunity by the host against antigens from the first crop of homografts. (17) However, if the interval of time between the first and the second crop of homografts in man is eighty days or longer, hostile antibodies against the second crop apparently are absent; therefore the second crop will survive as long as the first crop. (18) Persons with uremia and with severe burns show relative tolerance to skin homografts. Burned persons who are treated by homografting show a high blood level. (19) (20) In animals administration of cortisone and corticoids prolongs the survival of skin homografts. In man, however, the administration of cortisone or corticoids in nontoxic dosages has failed to prolong the survival of the grafts. This then suggests the high blood level of corticosteroids in a burned patient is not the single factor responsible for the prolonged survival of skin homografts. It is possible that bacterial and other antigens on the exposed burned surface affords such a barrage against the patient's immunologic system that it becomes exhausted and incapable of coping with antigens in skin homografts. Genetic factors must be considered in that homografts between mothers and children have been reported to take as high as 25% and fathers and children 0%. It has been reported that homografts with donations of fresh blood from the skin donor has prolonged the "take" of homografts. It has also been reported that pregnant women are very tolerant to homografts. It has also been reported that homografts were readily taken by people suffering with carcinoma, and fetal exchange has been readily acknowledged. (21) I realize this is gross digression from the subject under the discussion, but I feel the physician must be aware of the potentials as well as the problems inherent in skin grafting. As previously discussed, three weeks of observation may be necessary before definitive debridement of a burn wound should be attempted, as it often takes this long before accurate differentiation can be made between deep and second degree burns. When the open method is employed, grafting may be instituted following a natural or mechanical separation and removal of the eschar, if re-epithelialization has not taken place. Dressings should be applied immediately following removal of the eschar. When the wound is granulating, grafting should be started. Sterile saline soaks may foster the development of a clean wound. The type of skin graft employed depends on the area to be grafted and the amount of available donor skin. It should be kept in mind that the thinner the graft, the better will be the take, and the poorer the functional coverage. Conversely, the thicker the graft, the better the functional coverage, and the poorer the take. (6) Certain areas of the body should be given consideration for the coverage before others. Areas around joints are covered before large flat surfaces. A priority list for coverage has been suggested by Artz: Hands and face first, with special priority to the hands, then areas of motion, especially those about the elbow. It is wise to obtain coverage of the arms and hands as early as possible. This permits the patient to feed himself and improves morale. The area around the knee is next, then the anterior aspect of the lower leg, and the posterior aspect of the lower leg. An attempt should always be made to cover the areas of motion in order to lessen fibrosis, scarring and contraction. It becomes dealers choice then for the remaining areas. (12). Selection of donor sites should be predicated on the easiest and most accessible areas. The anterior aspect of the thigh, followed by the anterior aspect of the trunk are best. Several crops of skin must be taken from the same area if a patient has extensive burns. Depending on the thickness of skin, a second crop can be removed approximately three to four weeks following the first. The thinner the donor site is shaved, the more rapid is the healing of the area and the earlier a second crop may be taken. Avoid taking skin over bony prominences such as the skin over the tibia. If there is a choice between using the chest and the abdomen, the chest is preferred because donor sites in this area of decreased motion are less painful. If the donor sites are to be treated by the open method, the anterior aspect of the body is much the preferred as it is more comfortable to lie on the back for extended periods of time than the abdomen.

The selection of donor sites is also predicated on the areas burned and the type of dermatome to be used. The Brown electric dermatome takes a strip of skin three inches wide. It may well be the most useful as many thin sheets of skin may be removed quickly. Its construction is simple and little experience is required for successful removal of a large amount of skin. The disadvantage is that a flat firm surface must be available. The Padgett dermatome is a drum type particularly useful in obtaining grafts from uneven surfaces. It also furnishes the best method of cutting skin when a thicker piece is desired. It will cut wider than the Brown dermatome but not as long, an arc of about ten by 20 centimeters. It also requires a considerable amount of practice. A third factor must be considered in using this type of dermatome, which is the glue necessary to pick up the skin and adhere it to the drum. Little may be found on this subject, but the old surgical precept of fewer materials introduced into the wound, the more rapid will be the healing and fewer complications encountered. The Reese dermatome is essentially a modification of the Padgett type. Its advantage is that it is heavier and allows the surgeon to hold the instrument steadier when cutting. The Stryker electric dermatome is a modification of the Stryker cast and bone saw, giving it a dual purpose. The instrument is more difficult to use than the Brown instrument is more difficult to use than the Brown instrument, and it can only cut a strip of skin two inches wide. The earliest method of obtaining split thickness grafts was by means of the free hand knife. A double-edged razor blade held between the jaws of a straight hemostat or Kocher clamp may be used. The preferred type is the Blair-Brown knife, or the Ferris-Smith knife, both having replaceable blades. The advantages of these two types are: less expensive initially; cheaper upkeep; the blades are five to six inches long and the length of the graft is limited only by the surgeon's skill and donor area of the patient. Disadvantages are: great skill is required and it is almost impossible to cut a sheet of uniform width and thickness. As soon as the skin has been removed, it is placed in saline solution or on saline soaked gauze to keep it moist. The three methods employed in its application to the wound are: postage stamp, lay on and suture to the wound. Postage stamp grafts are cut one by two inches and placed on the wound in bricklayer fashion, not further than one half inch apart. They are easily applied when the skin has been taken with a Reese dermatome, as suturing the skin is unnecessary since the grafts are held in place by the dressing and dermatome glue backing. The lay-on method is best for applying split-thickness grafts to large flat surfaces. It is rigid and effective. A sheet of skin is placed near the recipient area, then the petrolatum gauze is removed. The skin is arranged in such a way that the sheets are placed in close apposition. Grafts are held in place by applying a firm dressing. This method cannot be used on irregular surfaces, as the skin is likely to become wrinkled or slip. Grafts should be sutured in place over irregular surfaces and points of motion, such as the chin, neck, feet, hands or around the knee or elbow. Very fine 4-0 silk sutures may be used on a sharp cutting needle. Deep bites into the underlying tissue must be taken in order to prevent excessive bleeding. Small perforations must be made in grafts other than postage stamp otherwise serum or blood might collect beneath the graft and prevent a good take.

One of the more important factors in grafting is the application of a good dressing. Most grafts are held in place by a dressing; therefore the dressing must be firm, bulky and capable of producing even compression. As soon as the grafts are applied, a layer of gauze lightly impregnated with petrolatum is placed over them. A large number of fluffs to make a bulky dressing are then added, after which an elastic bandage is wrapped around the dressing to provide even, firm compression. The dressing should be large enough to serve as a splint. If it does not completely immobilize the area, a plaster splint should be applied. Motion is one of the most important factors in the failure of a graft to take. Every dressing should be labeled by date of grafting and type of dressing applied. On-lay gauze dressing, commonly known as stented dressings, are extremely valuable for holding grafts in place over irregular surfaces. Heavy silk sutures are placed in normal tissue surrounding the area and tied over fluffed gauze. There are three important factors to consider in preventing take of a skin graft: Motion, infection and poor condition of the recipient site. Infection caused by group A beta hemolytic streptococci may produce sloughing of the grafts in a poor take. Other species do not seem to materially affect take of a graft when the bacterial population of the wound is unusually large. Motion is a very common cause of failure of graft take. Splinting procedures, as mentioned above, or sedation for twenty-four hours may be necessary. A poor recipient site affects the take of a graft adversely. Granulations having a fibrous base prevent grafts from obtaining a good blood supply. It is frequently difficult to estimate percentage of graft take after it has been in place for only three to five days. It is not necessary to remove sutures at the first dressing change. Following the initial dressing change, other changes may be carried out at two to five day intervals. Dressings must then be removed as soon as there is good graft take and coverage over all areas. The Hubbard tank is a good method for stimulating motion and keeping the grafted areas clean. As soon as the dressings have been removed on an extensively burned patient, it is advantageous if he is placed in a Hubbard tank at least once a day. When muscular tone returns, he may be considered ambulatory, as early motion and early ambulation are definitely to be denied. This is desirable in that it stimulates the patient's leisure to rehabilitate himself and thereby improves his morale. As soon as the granulating wounds are covered, a complete change occurs in the patient. He suffers less pain; he generally feels better; his appetite improves and he begins to gain weight. (12)

The road to recovery may be beset with many complications. The seriousness of the injury, the frequent administration of anesthetics, frequent operations, the prolonged bed rest, and the large number of other procedures required in therapy, all predispose to the occurence of a wide variety of complications. One of the most frequent and troublesome complications in burns is infection of the donor sites with conversion of the areas to granulating surfaces. Careful attention must be paid to the donor sites because infection may destroy the remaining viable epithelium. Occasionally when the donor site is taken too deeply, the area fails to heal and a granulating surface results. These areas must then be grafted and the full circle is met. Frequently the surgeon must accept a patient with severe contractures or massive keloids. Depending on the surgeon's ability, he may elect to remove the contractures by excision or Z plasty or refer him to a plastic surgeon. Contractures most frequently result from mal-positioning during formation of the eschar and during taking of grafts. It is essential to position injured parts properly in order to gain the best possible recovery of range of motion of joints after prolonged periods of immobilization. Proper positioning must be started immediately after injury and maintained until skin coverage is nearly complete. Because of contractures, certain positions of immobilation seem best for burned patients. In many instances, these are not necessarily the same as those described by the orthopedic surgeon as ideal for ankylosis of the joint. The neck may be kept in an extended position as it can be held without undue discomfort. The trunk and hips are maintained in an anatomical position. Almost complete extension is advised for the knees, regardless of the location of the burn. The ankles are maintained in flexion of ninety degrees to prevent shortening of Achilles tendon. The shoulders must be maintained in an anatomical position except in burns of the axilla, which require immobilation with the arm in ninety degrees abduction. A position of about one-hundred and forty degrees of flexion is suggested for the elbow. If there is a burn of the antecubital fossa in which there is danger of contracture in partial flexion, complete extension of the elbow is indicated. The metacarpal, phalangeal, and interphalangeal joints of the thumbs are kept in approximately fifteen degrees of flexion. The thumbs are abducted to maintain the breadth of the webb space. The metacarpo-phalangeal joints of the fingers must be immobilized in almost ninety degrees of flexion. This prevents contracture of the collateral ligaments and maintains length of skin over the dorsal surface of the joint. The proximal interphalangeal joint of the fingers are immobilized in thirty to forty-five degrees of flexion, and the wrist is extended.

Scars sometimes hypertrophy during or soon after the course of healing of a burn. In addition to being raised and hypertrophied, they differ from normal scars in that they remain pink or red for a long time and usually itch or burn. This hypertrophic state lasts for months or years, after which the scar slowly regresses and becomes thin, white and flat. Scar hypertrophy is far more likely to develop in children and young women. True keloids are at first undistinguishable from hypertrophic scars, but unlike the latter, they tend to spread into the surrounding skin and do not regress. The local factors are postulated to be intermittant tension and movement of the skin, a low grade infection, and the development of an atypical foreign body reaction. Glucksman claims that hypertrophic scars are the result of a foreign body reaction in the dermis usually related to dislocated hair fragments or follicles, cystic displaced sweat coils and other keratin debris, or maybe cotton-wool fibers, dust and talcum powder added to the wound. Certain groups such as Negroes are more prone to scar hypertrophy than others, and the susceptibility extends to particular individuals and families. The condition is more commonly seen in females than males, occurs frequently in girls with red hair or with fair complexions, and is not uncommon in children. Some relationship is found by the work of Geschecter and Lewis, who found a considerable concentration of estrogens and pituitary hormones in keloids, and this is supported by the experiments of Vargas, who produced keloids in monkeys treated with estrogens. (22) Gillman and his colleagues suggested that the well-known susceptibility of Negroes may be related to effects of chronic malnutrition endimic in the colonial and semicolonial territories of Africa and Asia. (23) Hypertrophic scarring has been most frequent in those injured by flash burns from the atomic explosions in Hiroshima and Nagasaki. These scars have usually been called keloids, but most of them have regressed months or years later and others may still do so. The major description of ulcer-cancer in old degenerating scars was that of the French surgeon, Marjolin, in 1828, but his account was actually preceded by the report of an English surgeon named Hawkins in 1825, who described two cases of carcinoma in old burn scars. In most cases the burn scars occurred in full thickness burns of the skin. Most carcinomas become flat indurated ulcers with raised or thickened edges, resembling other skin cancers, the remainder are bulky, protruding growths. The commonest sites are areas most frequently burned; the hand, head, arms and legs and when the hand is affected, it is always the dorsum.

SUMMARY AND CONCLUSION

The only conclusions that may be drawn from this paper are that burns are still serious injuries, and that they are still with us despite a wealth of safety education, experience, research and tragedy. Therefore, I offer this in lieu of conclusion and summary. I would like to re-emphasize the importance of burns as it affects the physician and the patient in this modern world.

It is true that during the last twenty years tremendous advances have been made in the treatment as well as the prevention of burns. It is also true that even greater advances have been made in our ability to inflict them. The rapid development of effective antibiotic therapy, cortisone, blood, plasma and plasma expanders, electrolyte therapy and grafting techniques were welcome adjuncts to the physicians armamentarium. All these played a significant role in patient salvage in World War II and the Korean conflict. However, equal advances were made by development and increased usage of hi-test gasolines, phosphorus bombs and shells, naplamn and flame throwers. Each advancement in burn management seemed to parallel new means of infliction. The advent of nuclear weapons has ushered in a new era of burn patient, and with it, unprecedented demands upon the physician. To illustrate this in compiled certain definitive stastistics. He has shown each explosive yield from ground zero will yield a definite number of calories per square centimeter, the radius and the square mile area at which second degree burns will be produced on bare skin, and compare with blast and radiation for total damage inflicted.

Table II
(See the following page)

Weapon yield	Rad. 300 Rem. Radius	Area	Blast 2.5 P.S.I. Radius	Area	2° Burn Cal/sq. cm. Radius	Area
1 Kt.	.5	.8	.6	1.1	4.1/.5	.8 miles sq.
10 Kt.	.7	1.5	1.3	5.3	4.7/1.3	5.3 miles sq.
20 Kt.	.8	2.0	1.7	9.0	5.0/1.8	10.2 miles sq.
100 Kt.	1.1	3.8	2.8	24.0	5.3/3.5	38 miles sq.
1 Mt.	1.6	8.0	6.0	113.0	6.2/9	254 miles sq.
10 Mt.	2.2	18.2	13.2	547.0	7.0/26	2,123 miles sq.
200 Mt.	2.5	19.6	16.0	804.0	7.5/52	3,126 miles sq.

From these data it may be seen that initial ionizing radiation at the 300 Rem. level increase in radius only by a factor of 5 between 1 Kt. and 20 Mt. explosions, and blast pressures of 2.5 P. S. I. increase by a factor of 27! Thermal radiation intense enough to cause second degree burns increases from a radius of .5 miles to 32 miles, or a factor of 64! It is obvious that burn injury is more likely to cause the greatest numbers of casualties in any nuclear explosion. The single atomic device behind the Hiroshima blast caused approximately 34,000 seriously burned persons. In his evaluation of this situation, Pearson has estimated with present methods of burn treatment, 170,000 professional people and 8,000 tons of medical equipment would be needed. As applied to this community of Omaha, I feel this shows quite accurately the gross inadequacies of existing methods of handling large numbers of severely burned patients. It is the duty of the physician not only to avail himself of the most up-to-date methods of burn management, but to aid in the compiling of information, research and new developments and concepts in this field. (23) (24)

(Sequentially Arranged)

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