THE TREATMENT OF THE SURFACE BURNS*

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UNTIL THE INTRODUCTION of physiologic methods of investigation into the clinic, the treatment of burns was merely the treatment of the surface wound. This was inevitable since the wound was obvious to physician and patient. In the last 50 years, with the recognition of hemoconcentration, the danger of the generalized shock of burns has been appreciated and an argument has developed within the profession as to which takes precedence in the treatment, the care of the surface wound or the care of shock. Even recently, men primarily interested in the shock picture say that nothing should be done to the surface until impending shock has been prevented or existing shock adequately treated.

Such emphasis on shock to the neglect of the surface treatment is wise if the surface treatment is one which leads to further shock. Débridement and cleansing under anesthesia is such a treatment.

Delay in the care of the surface wound, however, inevitably leads to bacterial contamination. With increase in contamination there is increased infection, and increased infection leads to shock as well as delayed wound healing.

Overemphasis on the surface treatment, to the neglect of that of shock and anoxia, and a tendency to attribute special virtues to a surface treatment, are also unenlightened. For example, when "toxins" were considered an etiologic agent in shock, tannic acid was advised on its presumed ability to fix *in situ* tissue toxins produced by the burn;[1] and reduction in the mortality of patients with burns has been ascribed to a surface treatment, whereas, in reality, it was due to better care of early shock.

The surface treatment cannot be divorced from the treatment of shock. It is the purpose of this article to outline a surface treatment which does not interfere with the life-saving treatment of shock yet tends to prevent bacterial contamination. This treatment is peculiarly suited to a catastrophe where the large number of burn casualties is out of proportion to the number of trained personnel. The problem of the therapy of shock is considered in a subsequent article.

THE SURFACE TREATMENT USED ON COCOANUT GROVE PATIENTS

Thirty-nine of the 114 patients brought to the Emergency Ward of the Massachusetts General Hospital from the Cocoanut Grove night club fire survived the initial few minutes and received treatment of their burns. Common to disasters, there was a pattern to the injuries. The burn pattern consisted of the hands, face, nostrils, mouth, the lower half of both corneas, and the scalp; and in the women, areas unprotected by adequate clothing, namely, the neck, arms, shoulders, back and legs. In addition to the pattern distribution, the back and legs of some of the men were burned. Burns

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of all degrees were encountered, many having third degree or full-thickness burns.

The burns were sooty and shaggy, with unruptured blebs. Many were cherry-red color from carbon monoxide poisoning. Some of them looked clean, others grossly dirty. Many of the patients had been crawling on the floor at the fire, others had been dragged out from piles of dead. Many of the dead, and some of the unconscious who lived had been incontinent of both urine and feces.

But one type of surface treatment was applied to the burns of the skin of all of the 39 patients. A bland ointment with protective dressing was applied without any preliminary débridement or cleansing, and antibacterial chemotherapy was given internally.

As the patients entered the Emergency Ward, either walking or on a stretcher, sterile towels were placed over the burned surfaces. No covering was put over the faces. Insofar as possible these towels were held in place as the patients were undressed and transferred from stretcher to bed. For those patients having burns of the back, buttocks, and upper legs, sterile sheets were placed on the bed.

A needle was inserted for the intravenous administration of plasma before the dressings were applied to the burned surfaces. In many this was done while the patient was still on the stretcher.

When a patient was settled in bed, the sterile towels were folded back and the burn surfaces covered with sterile boric ointment strips. These strips were applied by interns or medical students who were not only capped and masked but were scrubbed and wearing rubber gloves. *The burn surfaces were neither cleansed nor débrided.**

The boric ointment gauze of fine mesh was covered with sterile gauze to protect the wounds. Burns of the face, scalp, and of the extremities were bandaged with pressure. This was accomplished by adding roller elastic bandages on top of the gauze dressing. Over the burns of the trunk, large stockinet rolls were applied. The dressings of burns of the neck were held in place by ordinary gauze bandages. The eyes, after application of 5 per cent sulfathiazole ointment, were closed and were included in the pressure dressings of the head. Only the nostrils and lips were left uncovered.

As a final part of the initial surface treatment, two grams of sodium sulfadiazine were injected intravenously through the cannula or needle already in place for plasma transfusion.

This surface dressing, and the chemotherapy, completed the care of the wound. It was first aid and definitive treatments combined. The dressings were not changed until the fifth to tenth day, when boric ointment gauze was reapplied. To those burns which proved to be of second degree, no other type of dressing was applied. To those areas later proving to have deep de-

* The face and left hand of one patient (Case 17) was partially débrided and cleansed with soap and water before applying a dressing of 5 per cent sulfathiazole ointment. This was done before the general order was appreciated.

struction of the skin, wet dressings of boric acid or physiologic saline solution were used after the first two weeks in order to expedite the removal of the burned tissue, and prepare the surfaces for grafting.

Rationale of the Surface Treatment Employed.—The use of this unorthodox surface treatment was premeditated and prompted by the concept that of treatments giving approximately equal results, the simplest would be the one best adapted for a disaster with numerous burn casualties.

No Débridement and No Cleansing.—We did not débride the burn wounds because we were convinced that the intact epidermis over the blebs protects against the entrance of bacteria, and because bleb fluid does not become contaminated by virulent organisms harbored in gland crypts.

We did not cleanse the burn surfaces because we believe that cleansing is ineffectual in reducing significantly the number of contaminating organisms present unless vigorous scrubbing is resorted to. Such scrubbing, it is believed, injures viable epithelium. An anesthetic also would be necessary and is undesirable from the point of view of augmenting shock.

The débridement of burn wounds, as commonly carried out, consists not only of picking off particles of clothing and other foreign material but also in rupturing any vesicles and removing the overlying epidermis and all of the loose epidermis of the vesicles already ruptured. This is ordinarily followed by cleansing. Admittedly, débridement is necessary for good tanning, and, therefore, débridement and cleansing are part of the tannic acid ritual; they have been carried over into other methods of treatment without criticism. These maneuvers are time-consuming as well as painful. They tie-up available personnel and require analgesic drugs, if not general anesthetics. The increased manipulation of the patient, prolonged exposure of the wounds, and anesthetics attendant with débridement, are conducive to serious shock. If these maneuvers can be eliminated, the trained personnel will be freed and the prevention of further shock accomplished.

When nondébridement of burn wounds was suggested soon after Pearl Harbor, serious objections were raised. It was maintained that all blebs must be opened because bleb fluid would be an excellent anaerobic culture medium and because the bacteria harbored in the gland crypts at the base of the vesicle would swim up and infect the fluid.

On physiologic grounds the first objection seemed unreasonable. Superficial human burn wounds weep for many hours, and in dogs, Field, Drinker and White,[2] in 1931, showed that there was an increased flow of lymph induced by an experimental burn which continued for hours without clotting. These observations suggested a rapid turnover in the protein-rich fluid in the burn areas. The fluid comes from the plasma pouring through the open capillary membrane into the extracellular spaces and passes either out on to the surface or back through the lymphatics. Such a rapid turnover of plasma fluid should mean a relatively high oxygen content of the edema fluid in the burn area.

Against the second objection are the bacteriologic observations of Colebrook,[3] and others, [4, 5] pointing to the ability of skin to rid itself of patho-

genic bacteria. There are normal habitants of skin which are not sufficiently virulent to cause infection, and little trouble is to be expected from these. Virulent bacteria are destroyed, perhaps by the skin lipoids.[5] The heat producing the burn also decreases the number of bacteria present on the skin at the time.

Finally, it remained to find out in patients with burns what happened to the fluid of, and healing beneath, the unruptured vesicles. Twenty-six patients had been studied prior to the Cocoanut Grove fire. The fluid from more than one bleb was observed in many of the patients. In those arriving at the hospital with unruptured blebs, the blebs were protected by gauze to prevent rupture. Many of the patients' burns were hours to days old when first seen, and the blebs had not been protected from contamination by any dressing. From 24 hours to 14 days after the burn the fluid was removed from the vesicles under sterile precautions and cultured in Dr. Champ Lyons' laboratory. In a few instances, the nonpathogenic saprophytic organisms of normal skin were recovered. In only one instance was a pathogenic organism, a *beta* hemolytic streptococcus, obtained in fluid of an unruptured bleb, and in this case alone was the fluid purulent. It was the clinical impression that the healing beneath the unruptured blebs occurred as rapidly as under any of the agents commonly recommended for the burn surface.

Another objection which has been raised to nondébridement is that the dead epidermis of vesicles which have already ruptured provides a culture medium for organisms. Such broken epidermis usually retracts and is often found rolled up in a corner of the old vesicle. Admittedly, it looks messy and unsurgical, but how dangerous a culture medium is it and what do we accomplish by taking it away? If it is excised and a dressing applied, it will be replaced by a layer of fibrin between cells and dressing. As far as is known, this inert fibrin is as good a culture medium as the dead epidermis. Since unruptured vesicles are not infected, the under surface of the broken epidermis is presumably uninfected. Even though it now covers a lesser surface of the burn, it is still a protection and as physiologic as any that is now known.

A major point in favor of nondébridement of the burn wound is, as has been shown in this laboratory, the availability to the wound of chemotherapeutic agents administered internally. Absorption of sulfonamides applied locally to the débrided burn surface has been observed at this hospital by Dr. Lyons, and also reported in the literature. Such absorption may be rapid and irregular and if the burn surface is large, toxic levels of the drugs in the body fluids may be reached. (Absorption from a nondébrided surface has not been measured.)

The levels of the sulfonamide drugs in the body fluids are more easily controlled by internal administration. Therefore, if it could be shown that these drugs permeate through the burn tissue, this route would be preferable. Since sulfonamides are freely diffusible and there is an increase in capillary permeability in the region of the burn with delayed clotting of the edema

and bleb fluid, it seemed likely that free diffusion, in the early hours at least, would be found.

As anticipated, the level of the sulfonamides in the bleb fluid of unruptured vesicles followed closely that of the blood plasma. For example, a girl with a burn of the leg and a large unruptured bleb was started on sulfadiazine by mouth two hours after the burn. Twelve hours later a titer of 4.3 mg. of the drug was found both in the bleb fluid and blood plasma. Such observations were repeated on a number of the Cocoanut Grove fire patients.

It is not known for how long sulfonamides, administered internally, permeate freely through the burn wound. Fibrin is eventually deposited in the intercellular spaces of the wound and it is probable, when this stage of the inflammatory process is complete, that substances normally diffusible are no longer able to permeate through the wound in bacteriostatic concentrations. This is suggested by the findings in a patient treated since the Cocoanut Grove disaster. A hot water burn of the lower leg resulted in a large unruptured bleb. Sulfadiazine was withheld until 60 hours after the burn. At 73 hours the levels of sulfadiazine were 8 mg. in blood and 3.3 mg. in the bleb fluid. The time limit, if such exists, remains to be determined.

It seemed reasonable on the basis of these findings on the fluid of unruptured blebs (absence of virulent bacteria, good healing in its presence, and availability to it of internally administered sulfonamides) to treat burn patients with the greatly simplified surface treatment of no débridement, no cleansing, and a simple bland ointment with protective dressing. Several patients had been treated in this manner prior to the Cocoanut Grove disaster and the observations on them afforded an adequate basis for planning to use such a simplified treatment in a disaster with numerous burn casualties.

Boric Ointment: A bland, protective ointment dressing is indicated in the treatment of skin burns since the chemical agents currently recommended are believed to be injurious to otherwise viable epithelium and delay wound healing. In a previous communication from this hospital,[6] it has been shown that tannic acid, the dye solutions, and certain other preparations delay the healing of an epithelial wound. Use was made of the donor site, from which a skin graft of uniform thickness had been removed by the dermatone, for the assay of these various agents. This wound heals by epithelial proliferation with a minimum of fibrous tissue contracture. It is also a sterile wound and the retarding influences of various infectious organisms is eliminated as a complicating factor. Although it is not a burn wound and does not have the superficial layer of dead tissue created by the burn, from the point of view of healing it has much in common with the burn wound. Substances retarding healing in this donor site wound would presumably have the same action on the viable epithelium of a burn wound.

It is difficult, if not impossible, to assay accurately the effect of a chemical agent on epithelial regeneration using a clinical burn wound. There are factors other than the substance applied locally which influence

the rate of healing. There is no proven clinical method of judging accurately the extent to which the cells are damaged by the burn, and thus no two burned areas can be considered of identical depth or degree. Obviously, the deeper the burn, the slower the healing will be. Also complications of the burn, infection and malnutrition, delay the eventual healing. The effect on healing ascribed to an agent may be due in reality to the depth of the burn or to other factors.*

Boric ointment gauze was used as the control agent in these experiments upon epithelial regeneration. It is chiefly because this ointment is commonly used in hospitals for many purposes that it has been chosen for treating burns. Dr. Lyons feels that the boric acid in the ointment may inhibit the growth of the pyocyaneus organism. (It is known to rid granulating wounds of pyocyaneus infection.) The relative absence of this organism in the wounds in the patients treated in the disaster is a possible confirmation of this effect. It should be pointed out, however, that little is known regarding the absorption of boric acid from burn or granulating surface wounds, and since boric acid has been occasionally reported to give rise to toxic symptoms, it may prove wise after further investigation to omit the boric acid and use plain petrolatum for burns. In this way, excessive absorption from large areas would be avoided.†

A bland ointment usually gives prompt relief of pain. Apparently any oily substance, perhaps because it excludes air from the wound, is comfortable. If pain persists, it may be due to too tight a dressing.

Pressure Bandage and Splinting.—The indications for the use of pressure dressings on the extremities and face are not clear to us. Pressure dressings on the extremities do prevent the occurrence of massive edema beneath the bandages but may not prevent the loss of plasma. In the patients of the Cocoanut Grove disaster, the fluid which seeped out in the burned hands, and which would have formed edema locally, was expressed up the arm and produced massive edema. Edema of the burned faces developed despite the pressure dressings. Where the scalp was not burned in addition to the face, edema fluid from the face was expressed posteriorly and a generalized edema beneath the bandage was produced. Edema fluid was also expressed downwards into the soft tissues of the neck and over the shoulders and upper chest (color section Fig. 15 b). (Massive edema of the breasts devel-

* The solutions of both tannic acid and the triple dyes recommended for the treatment of burns are strongly acid, p_H 2.0 and 2.5, respectively. Neutralized solutions were not tried. It is possible that the retardation of healing was due to the acidity rather than to anything specifically involved in the tannate or the dyes.

† Since this article was written, the urine of 20 of the patients has been analyzed for boric acid. A maximum of 2 Gm. was excreted in 24 hours in the first two days in the patients with extensive burns. Later on when boric acid solution was used to irrigate the granulating wounds, as much as 2.5 Gm. were excreted in the urine in 24 hours. These levels are far below those of excretion reported in patients having toxic symptoms from boric acid poisoning. Since all our patients maintained normal kidney function it is probable that the excretion of boric acid was prompt, toxic levels from absorption were not approached, and the use of boric acid in petrolatum is safe.

oped in Case 13.) Distended, edematous tissues were encountered, on performing a tracheotomy where there was no superficial burns of the neck.

It is of course possible that an excessive edema beneath a burn wound may tend often to increase tissue damage. On the other hand, we have no evidence that healing was expedited in any of our cases by the use of pressure dressings.

Splinting of an extremity is comfortable and rolled newspapers were incorporated in an outer layer of the pressure dressings. Such splinting decreases lymph flow which may not be of benefit in a sterile burn wound but is in a septic wound. Lymph stasis facilitates the localization of the septic process.

Administrative Advantages of a Simple Treatment.—From the administrative point of view in handling casualties of a disaster there are many advantages of a simple treatment. The problems of personnel are the most important. In battle or in a civilian disaster there is inevitably a disproportionate number of trained medical personnel to casualties. The simpler the treatment, the fewer the trained personnel required to administer it. The treatment used on the patients at this hospital from the Cocoanut Grove fire can be applied by nurses or orderlies. Physicians present are freed for the administration of plasma for shock, and oxygen for anoxia. The operating room and a general anesthetic are dispensed with. The operating room facilities are freed for the care of other injuries. This hospital had seven operating rooms, with personnel, in preparation for the patients of this fire. When it was obvious that no injuries requiring operative treatment had been sustained, the personnel was made available for other work. There is no theoretic reason why burn wounds should have both first aid and definitive treatments. The elimination of the definitive treatment, a relic of the tannic acid regimen, spares much wasted effort on the part of personnel and discomfort to the patient.

Another advantage of a simple treatment from the administrative point of view is the problem of equipment, supplies, and their storage. Ideally, nothing should be required for the treatment of a burn which is not also useful for some other type of wound. The substances required for the treatment described are useful in other types of injuries. In contrast, the paraffin treatment with its heater and spray-gun complicates the requirements and rules out this method even though it may well give equally good results. Tannic acid and triple dyes have not been recommended for injuries other than burns. Such considerations of equipment are of paramount importance to the Army and Navy where transportation and storage are problems.

Medical Advantages of Simplicity.—The treatment of a heat burn should, ideally, be directed toward the prevention of its complications. Of these the most important are infection and shock. Since infection originates almost entirely from contamination with organisms arriving on the burn surface after the burn has occurred, the earlier the wound is protected, the less will be the infection. It is clear that the simpler the treatment, the sooner it can be applied.

Infection is to be avoided not only because of the shock due to infectious toxemia but also because it delays wound healing and adds to scarring. Indeed, it is probable that the growth of various organisms on burn wounds destroys otherwise viable epithelium and may convert a deep second degree burn into a full-thickness destruction of the epithelium. From the point of view both of survival and early convalescence, infection is most objectionable.

The simpler the treatment, the less manipulation there will be of the patient. From the point of view of aggravation of shock this is important. The rolling of the patient, incident to débridement and washing, not only increases pain but disturbs further the circulatory imbalance impending in shock. Since a simple treatment with minimal requirements of materials will be applied earlier, quicker relief of pain will be obtained, and this too helps to prevent shock.

Results.—The results of the treatment of the burn surface have been considered by the Staff as gratifying. The second degree burns healed promptly without evidence of infection, and with minimal scarring. Examples are shown in the colored photographs (color section Fig. 13 a–e, and color section Fig. 15 a–e). Of the deep burns, the wounds remained unusually free of active or invasive infection. In his article, Dr. Lyons details the course of bacteriologic flora of the wounds and the success of the chemotherapy. Cultures of the burn wounds were not obtained until the time of the first change of dressings so the amount and nature of the contamination present at the time of entry is not known. The subsequent lack of invasive infection was presumably due to the chemotherapy rather than to any unusual cleanliness of the burns on arrival for they were grossly dirty, and there were many chances for fecal and respiratory tract contamination before arrival at the hospital.

Clinical proof that the original surface treatment used, did not lead to infection, and, indeed, on the contrary, was effective in checking the growth of organisms which were present, is shown by the experience with the left hand of Case 2 (color section Fig. 14 a–j). Two extensor tendons were exposed on the dorsum of the hand and Dr. Cannon elected to graft the hand by burying it in the abdominal wall. Had there been active infection in this wound the tendon would not have survived, the graft would not have become attached, and the abdominal wall wound would have suppurated.

On the fifteenth day after the disaster, the isolation floor was closed. Sixteen patients by this time had been discharged home with lungs free of signs and with surface burns healed. Another patient with a small third degree burn of an ankle had been discharged on the fourteenth day to a Naval Hospital, the second degree burns having healed. (Seven patients had died as the results of the pulmonary complications.)

Of the 15 patients left in the hospital, four were held for residual pulmonary signs, the second degree surface burns of three having healed. (The fourth had no surface burns). These four were discharged from the seventeenth to the thirty-second day.

The patient with the central nervous system damage from anoxia re-

mained, the minor burns having healed by the tenth day. She was discharged on the sixty-seventh day.

The remaining ten patients were those with the third degree burns. Dr. Cannon describes in his article the wound healing observed in these. The last of these was discharged on the one hundred and forty-third day.

COMMENT.—The problem of débridement and cleansing cannot be categorically answered for all burns. If a burn surface has been rubbed in dirt, more infection may be avoided by débriding and cleansing. In some cases a sluice of water over the surface without débriding may be nearly as effective as any other method. The point to emphasize is that neither débridement nor cleansing are essential to the good care of burns. Good surgical judgment in their care, as in that of many other diseases, consists of knowing when not to interfere.

The advisability of using pressure dressings on extremities and face has not been settled by the care of the patients of the Cocoanut Grove fire at this hospital. The dressings undoubtedly tend to restrict the loss of plasma and, therefore, the decrease in plasma volume but they do not prevent it, particularly in deep burns of the face and scalp when the edema fluid collects in the neck and over the shoulders and chest. A point more important to settle than the effect of pressure on the loss of plasma volume, however, is whether local edema of the burn tissue is harmful and whether pressure improves the local nutrition. We have obtained no objective evidence on this point.

CONCLUSIONS

A treatment for the surface wounds of burn casualties is described and its rationale discussed. It consists of no débridement, no cleansing, a bland ointment with protective dressing and internally administered chemotherapy. It was given extensive trial on the surface burns of the casualties from the Cocoanut Grove fire treated at the Massachusetts General Hospital and proven eminently satisfactory. Its advantage lies in its simplicity. The available personnel is freed for the care of shock and anoxia, yet the surface wounds need not be neglected.

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