ANNALS OF SURGERY
VOL. 118 NOVEMBER, 1943 No. 5

THE SURFACE TREATMENT OF BURNS*

A COMPARISON OF RESULTS OF TANNIC ACID, SILVER NITRATE, TRIPLE DYE, AND VASELINE OR BORIC OINTMENT AS SURFACE TREATMENTS IN 150 CASES

GEORGE H. A. CLOWES, JR., M.D.,† CHARLES C. LUND, M.D.,
AND
STANLEY M. LEVENSON, M.D.
BOSTON, MASS.

DURING THE PERIOD August 6, 1942, to March 10, 1943, there were 212 cases of burns given surface treatment by one of three standard methods at the Boston City Hospital. All of these cases were serious enough to warrant admission to the wards of the hospital. Of them, 109 came from the "Cocoanut Grove" disaster and 103 at other times. Certain cases have been excluded from the present report because there is no way of using them in evaluating the efficiency of surface treatment. The largest group of these exclusions are 33 "Cocoanut Grove" cases, and four other cases that had severe respiratory involvement as well as external burns, and whose death was so largely contributed to by the respiratory factor that evaluation of surface treatment was impossible. All of these deaths occurred within 12 days after injury.

Other groups excluded are patients who were discharged early and "lost" at a time when the depth of the burn could not be estimated, and a few cases who came to the hospital over 48 hours after their burn and cases where other than standard primary surface treatments were used. There remain 150 cases that form the basis of this report. Experimental surface treatments were used on certain areas of some of these cases. The results of the treatments to these areas are not considered in this report. No experimental primary treatments were used on any of the cases from the "Cocoanut Grove" fire.

Table I shows the age and sex distribution of these cases.

The sporadic cases of burns admitted to the wards of this hospital are due to many agents and the patients are of all ages from infancy to extreme old age. Usually about half the patients admitted are children and half of

* From the Burn Assignment of the Surgical Services of the Boston City Hospital, and the Department of Surgery, Harvard Medical School. The work described in this paper was done, in part, under a contract recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Harvard University.

† Now Lieutenant, M.C., A.U.S.

TABLE I

STUDY OF SURFACE TREATMENT

DISTRIBUTION OF CASES BY AGE AND SEX

	Male		Female		Total		
Ages	C. G.*	Other	C. G.*	Other	C. G.*	Other	Total
0–4	0	17	0	2	0	19	19
5–9	0	10	0	4	0	14	14
10–19	2	10	2	3	4	13	17
20–29	21	1	16	1	37	2	39
30–39	10	4	8	5	18	9	27
40–49	2	9	0	4	2	13	15
50–59	1	5	0	3	1	8	9
60–69	0	2	0	3	0	5	5
70–79	0	0	0	1	0	1	1
Unknown	1	1	2	0	3	1	4
Total	37	59	28	26	65	85	150

*Cases burned in the Cocoanut Grove disaster.

them adults. About half the burns are caused by scalding with hot aqueous fluid (water, tea, coffee, soup, *etc.*). About 40 per cent are flame burns. The remainder are burns from miscellaneous causes such as hot oils and greases, molten metal, hot nonmolten metal, acids, other chemicals and electric flashes, *etc.* The patients are usually from the poorer economic strata of the community and a fair percentage are poorly developed, poorly nourished, and anemic. Adults burned in bed or whose clothing has been on fire are frequently intoxicated and many of them are in a state of chronic alcoholism.

In sharp contradistinction to the usual group of patients were those burned in the Cocoanut Grove disaster. They were mostly young adults in excellent physical condition. Very few, if any, were under the influence of alcohol. It has been estimated that the average patient in this group had consumed the equivalent of two cocktails (25 cc. of pure alcohol) during the three hours preceding the fire. There was only one known chronic alcoholic among these cases. All of these burns were flame burns and none of them scalds.

CLASSIFICATION OF BURNS

For the purpose of this report only second and third degree burns are discussed. Second degree burns include all burns, no matter how deep, that destroy only a part of the epithelium. Third degree burns include only those that destroy the whole epithelium. The appearance of the burn on admission and for some time thereafter, is frequently not a reliable guide to the depth of the burn. However, many small blisters, slight edema of the skin, weeping of broken blebs with a pinkish color of the corium under the blebs, indicate the presence of a second degree burn. On the other hand, charring, dry dead white, or brownish, leathery appearance without edema below it, indicate the presence of a third degree burn. There is, however, a rather large group of cases that cannot be finally classified until they are either well on toward healing in the case of second degree, or granulating in the case of third degree (Fig. 1 A-D). This study is based entirely on a classification of the cases at a time after the injury when an accurate estimate as to

depth and of the areas involved in each depth could be made. The percentages of body area involved were calculated by the use of Berkow's[1] formula.

PRELIMINARY TREATMENT

On entering the accident floor the patients were seen by an admitting physician, given suitable doses of morphine, and undressed. Ordinarily, patients without shock were sent to the operating room for prophylactic plasma therapy, if needed, and initiation of surface treatment. A few very severely burned patients were sent to the "shock room" of the accident floor and treated there until death or beginning recovery. The Cocoanut Grove patients were given morphine in the accident floor as usual but they were not undressed until they arrived in the operating room or the wards. About 35 of these patients were treated in the operating rooms. The rest were placed in bed in the wards and treated there, because of limited operating room facilities.

TANNIC ACID-SILVER NITRATE TREATMENT

The tannic acid-silver nitrate treatment was used only on burns of the body, legs, and arms. A rapid tanning after removal of loose débris and washing was made according to the accepted treatment described in the U. S. Army Manual.[2] Freshly dissolved 10 per cent tannic acid solution in water was applied to the whole area. Then the remainder of this solution was added to an equal amount of 10 per cent silver nitrate solution making a solution of 5 per cent of each. This was applied at once and every half hour for four applications. Anesthesia for the cleaning was used in some cases, particularly in young children. After the fifth application of the tanning solution, a dry, firm, rather thin, moderately elastic eschar was formed. A cradle with moderate heating by electric lights was used to promote the drying. Sterile sheets were not used. If the eschar remained intact and clean it was allowed to remain until it came away spontaneously. This occurred only in a few second degree burns. It was found that these eschars were relatively impervious to moist solutions once they had dried out. In all the third degree cases signs of softening with infection under the eschar appeared in from four to eight days (Fig. 1 A-D). The eschar was excised over such areas and secondary treatment initiated.

TRIPLE DYE TREATMENT

From the beginning of the study until the night of the Cocoanut Grove disaster, no dye treatments were used. But for many years previously, as a result of the important investigations made by Aldrich,[3] "triple dye" had been the treatment most used in this hospital for severe burns. For two reasons it was used extensively on the patients from the Cocoanut Grove. Supplies of silver nitrate were rapidly exhausted and many staff surgeons not connected with the Burn Assignment were called in and were permitted to use the dye treatment with which they were most familiar. In the six weeks following the disaster a few additional cases were also treated in this way.

Triple dye is a water solution containing gentian violet, methyl green and acriflavine. It is claimed that when properly used it has bacteriostatic properties against both gram-positive and gram-negative organisms. Aldrich[4] has recently advocated its use without previous cleaning unless gross soiling of the burn has occurred. In the present cases a moderate amount of cleaning (breaking of blisters and removal of loose sheets of broken epidermis) was carried out in many cases. In some, soap and water washing of the surface was also done. On the night of the disaster many cases were treated with applications of this dye to burns of all parts of the body including hands and face. During the period of application the patient was protected from the contact with bed clothing by a cradle with lights and the solution was brushed on with a sponge every one-half to one hour. An eschar was formed much more slowly than with tannic acid-silver nitrate, and applications were continued up to 24 hours in most cases and to 48 hours in some (Fig. 3 A-E).

These eschars are much more sensitive to moisture than the tannic eschars. They soften and break down rapidly not only on application of ointments or saline dressings but also as a result of lying on them for a very few hours. If softened as a result of moisture without grease, they may, however, be repaired by a further application of the dye followed by a further period of drying. Even after infection has been established on the granulating surface under the eschar, the surface may be wiped and redyed. Such a secondary eschar is not as satisfactory as the original one but it does cover the open surface to some extent. However, such areas must be inspected daily and collections of pus unroofed and the granulations redyed.

1A. Flame burn after cleaning and before tanning. Note that the apparent depth of the burn of the left buttock and of the right calf seem to be equal. The small wounds were biopsies.

1B. Fourth day, after tannic acid-silver nitrate. Close inspection shows a "blister" on medial edge of right buttock. The fluid from this cultured colon bacilli.

1C. Twelfth day. The eschar was excised daily where it softened and saline dressings were applied. The infection became mixed and later the child lost much weight. Note the similar appearance of the necrotic tissue under the eschar of the two buttocks.

1D. Twenty-eighth day. The left buttock is healed indicating that this area was a second degree burn, but the right burn was third degree even on the calf. In this case the first sure evidence of depth of burn was after three weeks. Recovery without deformity followed Thiersch grafting. Final determination of area of burn was second degree, 6%, third degree, 10%. The burn extended beyond the limits seen on any of these photographs.

2A. Seventh day, at the first change of dressing after treatment with vaselined gauze and a firm voluminous dressing.

2B. Twelfth day. The same treatment was continued.

2C. Twenty-third day. Small Thiersch grafts put on part of the granulations as an experiment.

2D. Twenty-ninth day. The grafts are alive and remained so. Further grafting was done later. Final determination of area of burn, second degree, 4%, third degree, 16%.

FIGURE 1.—M. F., age 10, admitted August 24, 1942.
FIGURE 2.—F. P., age 40, admitted February 3, 1943

MIXED TANNIC ACID AND DYE TREATMENT

In some of the Cocoanut Grove cases eschars were started with tannic acid-silver nitrate and completed with triple dye. This procedure was never used at any other time. Since such eschars seem to have more of the physical characteristics of the underlying tannic acid-silver nitrate than of the overlying triple dye, they are classed with the other tannic acid eschars.

OINTMENT TREATMENT

Autoclaved strips of fine-mesh gauze impregnated with vaseline and of wide-mesh scrim impregnated with boric acid ointment were used for the treatment of many areas of burns of the hands, face, feet, or genitalia of all patients otherwise treated with tannic acid-silver nitrate and of some patients treated with triple dye. Such ointment dressings were also applied to the bodies, arms, and legs as the only treatment of other patients (Fig. 2 A-D). Until after the experience at the Massachusetts General Hospital in treating other victims from the disaster became known,[5] burns treated in this manner were always débrided and cleaned before the application. Commencing in February, many of the cases were treated with vaseline without cleaning (Fig. 2 A-D). Pressure dressings of the type and efficiency described by Allen and Koch[6] were not used except for a few cases. Burns on the faces of some cases were treated by the application of vaseline or boric acid ointment unsupported by gauze of any kind. No difference in results have been observed distinguishing vaselined gauze from boric acid ointment. For the purpose of this study they are both tabulated under the heading "ointment."

SECONDARY TREATMENT

Vaselined gauze, boric ointment gauze, and saline, boric acid, or weak Dakin's solutions were the chief applications used in secondary treatment. In general, if good progress was being made with ointment dressings these were replaced at intervals of five to seven days until healing or the necessity for grafting was demonstrated. When the time for grafting approached a change to frequent moist dressings was made. Tannic acid eschars on deep burns frequently had to be removed at the end of the first week because of underlying infection. This was done in part by application of vaselined gauze or wet dressings. Many of the triple dye eschars were also removed in the same way at an early date. One patient in the Cocoanut Grove group, with a 20 per cent area of third degree burn, became very toxic, and it was thought that infection under the eschar was responsible. The eschar was being removed by vaselined gauze and saline dressings. At one dressing an overenthusiastic application of sulfanilamide powder resulted in typical sulfanilamide toxemia, with cyanosis. The plasma sulfanilamide level rose to 20 mg. per cent. Sulfanilamide powder was utilized in this manner only in this one case. In a few cases triple dye eschars were retained for several weeks, repairing any softened areas by redyeing (Fig. 3 A-C). This was

done only in patients that were so toxic that any change in treatment was felt to be dangerous.

All the patients with second degree burns suffered very little pain at any time following the first dressing, but most of the patients with third degree burns suffered greatly and became extremely sensitive to very slight trauma. This was especially true if wet dressings were allowed to become partially dry before changing. Some of the more severely burned patients were given morphine or general anesthesia at the time of some dressings. Because of pain a few patients were treated with sulfathiazol ointment, cod liver oil ointment and with "eusol"* solution primarily because of the good psychic effect that frequently follows a change of method. Some of the patients felt that these changes were beneficial as far as pain was concerned. No other benefit was observed.

A few cases with deep burns of the hands and forearms had slow separation of their sloughs. Their dressings were often very painful. In eight instances Bunyan envelopes†[7] were used as a means of supplying irrigation with saline solution or Dakin's solution. This method of treatment at this stage was successful in relieving a large degree of the pain in six out of the eight patients so treated. It has been recommended that the fluid be drained periodically. The cycles used varied, with the period of filling from 20 minutes to one hour and the empty period from two to four hours. Bunyan advocated the instillation of oxygen when the fluid was out in order to keep the membrane from contact with granulations. Most of our patients preferred not to have the oxygen instilled, as they were more comfortable without it in spite of the fact that the upper surface of the empty bay lay against the granulation tissue.

Splints were used early and freely in burns of the forearm and hand and occasionally for burns of the legs. The splints served to reduce the amount of pain and to rest the part by reducing the possible range of motion in the wrists and finger joints and also served to prevent contractures. In the early days after the Cocoanut Grove disaster, a straight anterior splint with the fingers extended was applied to many patients with deep burns of the posterior aspect of the hand and fingers. From the point of view of pain, this was certainly useful, but it is very doubtful that this form of splinting should be used in the future, because posterior contractures occur rapidly. Splinting in the neutral position may avoid part of this difficulty.[8, 9]

* Edinburgh University solution—equal parts of liquid petrolatum and a solution containing 1.25 per cent boric acid and 1.25 per cent calcium hypochlorite, emulsified immediately prior to use.

† These envelopes were kindly furnished by the Union Carbide and Chemical Corporation.

THE RELATION OF SHOCK AND HEMOCONCENTRATION TO SURFACE TREATMENT

Death from shock occurred in only one instance. This was in a patient with flame burns of 60 per cent of her body surface treated with tannic acid-

silver nitrate, who received a very inadequate dose of plasma, 1000 cc., quite large amounts of electrolyte solutions intravenously, and died at 22 hours.

Tannic acid-silver nitrate treatment controls surface leakage after it has been applied. Triple dye controls it more slowly. Vaselined gauze without pressure allows it to continue until it stops spontaneously. None of these treatments controls the subcutaneous loss of plasma which may be very large in amount and in fact may be much more important than the surface ooze. It is possible that well applied pressure dressings do control this loss and the loss through the surface to some extent,[10] particularly on the hands and forearms. Subcutaneous edema is most marked in the face and very difficult to control by pressure.[5] No effort was made to control it in this group of cases. The maximum swelling was seen at 24 hours. At seven to ten days it had disappeared entirely.

Careful washing was used regularly up to the night of the disaster for all cases. After it, it was used less and less, and given up entirely as soon as the good results of ointment and pressure treatment without scrubbing that were secured by Cope[5] became known. That cleaning itself can add to shock is understandable. First, it may entail a fair amount of manipulation and either pain or anesthesia, both of which are harmful. But most important, it frequently may start up a very visible surface exudation that had previously ceased. Further discussion of these important matters will be made in other articles.[11, 12]

3A. A very satisfactory "triple dye" eschar on the thirteenth day. How much of this burn is third degree?

3B. On the 19th day, saline dressings were started. This is its condition on the 21st day.

3C. Hands on the 32nd day. The original treatment of the two hands was the same. The eschar was deliberately removed from the left hand but not from the right by wet dressings started one week before this picture. This indicates that readiness for grafting in eschar-treated cases depends to some extent on the time that secondary treatments are started.

3D. Back on the 37th day. This area was ready for grafting prior to this time but delay was necessary because of poor general condition.

3E. Back on 64th day, 17 days after a completely successful grafting of part of the area. Note, here also, that whether a burn was second or third degree could not be told until the eschar was removed. Final determination of area of burn, second degree, 10%, third degree, 20%.

4A. After cleaning. This burn was due to hot water.

4B. On the fifth day. Notice that much blistering had occurred under the dressing. This indicated a gentle débridement at an early hour. It also indicates that it may be as difficult to distinguish early between a first and a second degree burn as between a second and a third degree burn. This dressing was removed unusually early in order to see the results of treatment.

4C. Eleventh day. The burn is nearly healed and was healed and dry on the fourteenth day. Pigment returned later. This was a second degree burn of rather superficial nature and of remarkably even depth. Final determination of area of burn, second degree, 20%, third degree, 0%.

FIGURE 3.—A. D., age 30, admitted November 28, 1942.
FIGURE 4.—P. F., age 20, admitted January 21, 1943.

POSSIBLE TOXIC EFFECTS OF SURFACE AGENTS USED

Very recently instances of tannic acid poisoning have been reported.[13, 14] In general, such reports have incriminated slow methods of tanning rather than the rapid tanning used in these cases. No instances of central necrosis of the liver have been seen in any of the cases in this series coming to autopsy. Neither triple dye, boric acid ointment, nor vaseline have ever been shown to be toxic. One patient, mentioned above, had a temporary toxic level of sulfanilamide from surface application of this drug.

One death only in this series occurred in the interval of time during which Wilson[15] considers deaths from burns to be toxic deaths. This patient was treated with tannic acid-silver nitrate. She died on the fifth day with thrombocytopenic purpura, anemia, edema, azotemia, and anuria.

INFECTION IN SECOND DEGREE BURNS

There were 75 cases in the present series having only second degree burns. These varied in area from just under one per cent to 20 per cent of the body surface. Seven were treated with tannic acid-silver nitrate alone, 59 with vaseline alone, one with triple dye, and eight with triple dye on some areas and vaseline on others. Many of these patients, burned in the Cocoanut Grove disaster, had additional pulmonary damage. About half of the whole group had temperatures of 101.0°F., or more, some time in the first three days, and a few reached 103.0°F., for a few hours during this time. The other half had normal temperatures at all times. All of the cases with an early rise had essentially normal temperature charts from the third day to complete healing of the burn with five exceptions. Two children had fever associated with upper respiratory infections and one child had a febrile reaction from the administration of serum. One unexplained rise of temperature to 105°F. on the fourth day occurred in a seventy-year-old woman. It is presumed that this fever, which lasted for 48 hours and suddenly receded, resulted from infection with a new organism that entered the burn, although there was no sign of cellulitis, lymphangitis or of intercurrent infection. In one man the temperature rose on the 14th day to 102.0°F., just before healing became complete, and this reaction was associated with lymphangitis. A culture from the burn at this time demonstrated a beta hemolytic streptococcus. These two infections both occurred in vaseline-treated cases and both subsided promptly on treatment with sulfadiazine, and did not delay the healing of the burns. In the first case no prophylactic sulfadiazine treatment had been given, but the second case had had full doses of sulfadiazine for eight days. Half of all these cases had been given oral sulfadiazine for 8 to 21 days beginning at 12 to 36 hours. This incidence of three per cent of clinical infection in 67 cases treated in whole or in part by vaseline, and of no infection in seven tannic acid treated cases, and eight treated with triple dye, indicates these treatments are safe treatments from the point of view of infection in second

degree burns even when sulfadiazine is not given as a precautionary measure. It also indicates that infection was not an important problem in these cases with second degree burn only. The patient with the largest area of purely second degree burn (scald) had 20 per cent involvement. Treatment was with vaselined gauze in large part and an experimental treatment in smaller part. There was never any fever (Fig. 4 A-C).

HEALING OF SECOND DEGREE BURNS

The end-point of healing in second degree burns, used as a criterion in the various cases treated, is the time when intact epithelium without crusts or sloughs adhering to it covers the whole area of the burn. Table II presents this data for the cases in this series. More areas are tabulated than there are cases because in many instances more than one kind of treatment was used and different areas had different end points. For instance, in an extreme case four areas might be studied on one patient. Second degree areas in cases also having third degree burns are included.

TABLE II

STUDY OF 150 BURNS

HEALING OF SECOND DEGREE BURNS

Area Involved	Face		Back		All Other	
Treatment	No. of Areas	Av. Time (Days)	No. of Areas	Av. Time (Days)	No. of Areas	Av. Time (Days)
Ointment.....	68	11	7	19	90	15
Tannic-silver.....	0	—	6	27	19	24
Triple dye.....	4	13	8	25	19	16
All treatments...	72	11	21	23	118	18

Table II shows that irrespective of treatment, healing of the face is rapid, of the back, slow, and the rest of the body, intermediate. It does not show any shorter healing time of those burns treated with ointment over that obtained with triple dye except, possibly, in burns of the back. The slight advantage of ointment over tannic acid in length of healing time extends to all areas studied.

Reasons for the rapid healing of the face and slow healing of the back can only be speculative. In favor of rapid healing of the face is a copious circulation, possible conditioning of the skin to thermal trauma by exposure, a firm connection to the underlying tissues, numerous subcutaneous glands of epithelial origin, and relative freedom from trauma during the period of healing. The main reasons the back may heal slowly are that the skin is thick and, therefore, a burn which is deeper than is possible in other areas may still be a second rather than a third degree burn, and that, during healing, trauma (from lying on the back) may be frequent. These burns cannot strictly be compared with those of other areas.

Further analysis of the available data permits the following additional statements to be made:

1. Areas of pure second degree burn heal no more rapidly than the areas of second degree burn associated with areas of third degree burn.

2. Areas of second degree burn heal as rapidly when extensive as when small, within the limit of size observed (20 per cent of body area).

3. Second degree burns of the anterior part of the body, buttocks, thighs, legs, feet, arms and hands all give the same range and average time of healing. The number of cases of burns of the palms of the hands and soles of the feet is too limited to allow any judgment as to healing of this specialized skin.

4. The range of time of healing varies directly with the depth of the second degree burn. This range is narrow for the face, five to eighteen days, and wide for the back, seven to fifty days irrespective of type of treatment. All other burns show a range of healing of six to twenty-four days with either ointment or triple dye treatment, but a wider range of sixteen to ninety days with tannic acid-silver nitrate.

5. Second degree burns from scalds take as long to heal as those from flame burns. Scalds, however, have caused much wider areas to be involved in second degree burns without any parts of the burn being of third degree depth than have been seen in this series to result from flame burns.

INFECTION IN THIRD DEGREE BURNS

It is widely known that bacteriologic asepsis cannot be maintained for any length of time in third degree burns no matter what treatment is used. This infection is frequently very serious. Even under the most meticulous aseptic conditions staphylococcal infections are nearly universal and streptococcal and colon bacillus infections numerous.[16] In general, cultures taken from the infected surface of a burn show mixed infections. This is true of the cases in this series.

Infection occurs in or under the dead sloughing skin or eschar and always permeates or extends under it in time. For this reason it is important to consider the surface area exposed to toxic absorption. Table III shows the extent of third degree burns in the cases studied in this series.

All these patients received sulfadiazine beginning at 12 to 36 hours and continuing for fairly protracted periods of time. Very little important infection occurred in the 57 cases with nine per cent of area or less of third degree burns. Two children contracted a scarlet fever rash three days after the burn, probably not related to the treatment. Seventeen others had fevers of over 101°F. at some time after the first week. But in all these cases the fever lasted only a few days. None of these patients died.

The aseptic precautions taken on these cases were not as strict as might be desired. But certain essentials were rigidly carried out. If dressings were used they were large occlusive dressings infrequently changed. Attendants were masked and the careful aseptic technic was used when dressings were changed. The relative freedom from severe infection in these cases confirms the findings of Lyons,[16] that if pathogenic bacteria are present on the original surface of the burn they will die out rapidly under innocuous dressings and rest. Therefore, efforts should not be as much directed toward

TABLE III

STUDY OF 150 BURNS

AREAS INVOLVED IN CASES WITH MIXED SECOND DEGREE AND THIRD DEGREE BURNS

Total Area Burned % of Surface Area	Third Degree Burn % of Surface Area	Cases from C. G.	Cases from Other	Total
	0–1.5%	12	13	25
	2.0–6%	8	11	19
0–9%	Total	20	24	44
	0–2.5%	2	0	2
	3–6%	2	5	7
	7–9%	2	1	3
	10–16%	1	3	4
10–24%	Total	7	9	16
	5–9%	1	0	1
	10–19%	2	2	4
	20–24%	4	1	5
	25–35%	0	1	1
25–49%	Total	7	4	11
	45–49%	1	1	2
	55%	0	1	1
	No Estimate	0	1	1
50% plus	Total	1	3	4
	Grand Total	35	40	75

killing bacteria necessarily present as to preventing the addition of new pathogenic strains at later dates.[17] Attention to dust was not possible in this series.

The 18 patients with ten per cent area or more of third degree burn all had important infections, with fever for some time except for the patient mentioned above who died in shock at 22 hours after admission and the patient that died in five days with thrombocytopenic purpura, anemia, edema, azotemia, and anuria. The infections occurred irrespective of surface treatment employed and in spite of adequate sulfadiazine treatment.

The bacteria cultured from these cases with large area burns were no different from those cultured from the smaller ones. The larger the area the greater the constitutional reaction and the greater the loss of protein from the surface. All of these patients were definitely sick with fever, high leukocyte counts, loss of appetite, and all the other symptoms of acute infections. However, in no case was there any spreading infection from the edge of the burn into or under the adjacent skin or elsewhere.

NUTRITION IN SEVERE BURNS

All the patients with ten per cent of surface area, or more, involved in third degree burns became serious nutritional problems because of the losses of nitrogen in the urine and from the surface, and because of the increased nutritional requirements resulting from infection with fever.[18] All patients were started on high protein, high vitamin diets designed to give them double the normal protein intake and five times the normal vitamin

intake. This diet contained 140 Gm. of protein. Vitamin supplements were given to secure the following intakes: A, 25,000 units, D, 2000 units, thiamin, 10 mg., riboflavin, 15 mg., nicotinic acid, 200 mg., and asorbic acid, 300 mg. This took care quite adequately of all the cases with second degree burns or of third degree burns up to nine per cent. Much higher intakes of protein have been demonstrated to be needed by the cases with larger area burns.[18, 19, 20]

In addition, the amount of nitrogen losses and requirements are definitely proportional to the area of third degree burn. This is contrary to the findings of Cope,[21] and his associates. Presentation of data and further discussion of this important subject will be made in another communication.[18]

ANEMIA IN SEVERE BURNS

Ham,[22] and his associates, have shown that there was an early hemolysis with hemoglobinuria in some of the cases in this series. Later, a severe and persistent anemia developed. This latter finding has been reported by most authors working in this field for many years. In this series this anemia was combatted with iron and with frequent whole blood transfusions. It was very persistent in some cases and 500 to 1000 cc. of blood were given weekly for long periods of time.[23]

RESULTS OF TREATMENT OF THE 16 MOST SEVERE BURNS

Table IV shows the 16 most severe cases divided according to area involved, method of treatment, and result. In a few of these cases, minor areas were treated with experimental treatments. Such cases are classed according to the treatment of the major part of the burn. Also, if vaseline was used on hands or face and an eschar on all other areas, the case is classed according to treatment of the major area.

Table IV shows a very striking relation between the size of a third degree burn and the survival of the patient. Only three out of 11 patients with 20 per cent, or more, of the surface area destroyed by a third degree burn survived while none of the five patients with ten or 15 per cent of body area so destroyed died. This indicates that there is a critical area of third degree burn at about 20 per cent, beyond which the efforts employed in this series have not been able to save the patient. No conclusive evidence of the superiority of one type of treatment over either of the others can be derived from statistical analysis of the data.

The deaths were all preceded by great loss of weight and strength in spite of dietary measures, transfusions and other supportive treatment. The deaths were all relatively late, occurring on the following days after injury; 16, 25, 28, 32, 39, 80, and 157. In all studies of burns treated prior to the advent of plasma, these patients would probably have died of shock or "toxemia" at a much earlier time.

HEALING OF THIRD DEGREE BURNS

In a study of the efficiency of primary surface applications to third degree burns the true end-result, that of complete surface healing, cannot

TABLE IV

STUDY OF 150 BURNS

MORTALITY AFTER THE SECOND WEEK BY AREAS AND BY PRIMARY TREATMENT OF THIRD DEGREE BURNS

Per cent Area of Third Degree	Ointment		Tannic Acid-Silver Nitrate		Triple Dye		Total	
	Lived	Died	Lived	Died	Lived	Died	Lived	Died
10	1	0	1	0	0	0	2	0
15	1	0	0	0	2	0	3	0
20	1	0	0	5	1	0	2	5
35	0	1	0	0	0	0	0	1
45	0	0	0	1	1	0	1	1
65	0	0	0	0	0	1	0	1
Total	3	1	1	6	4	1	8	8

be used. Too many totally extraneous factors such as the technical success of grafting, the number of grafting operations; the severity of infection; the presence of anemia; and the state of nutrition are some of these factors. Two possible end-points, neither of which is ideal, may be used as rough guides to the efficiency of any application to such a burn. The first is the time of disappearance of gross slough, which is not a sharp end point and somewhat subject to "subjective" errors. The second criterion that may be used is not subjective (from the standpoint of statistical analysis), and that is the actual time of performing the first graft. As a test of a certain stage of healing this is far from perfect because any given patient may be operated upon too soon and, therefore, fail and another may be done later than necessary due to reasons that have nothing to do with the actual healing process. The time of the first successful graft would be a very poor test because the failure of a graft may be the result of technical errors and not due to any factor of unreadiness in the wound. During the earlier months of study it was thought that grafts could only be successful if all slough was removed, there was no fever, and no anemia, and no clinical infection. Later it was found that grafts could be successful even when put on areas of granulation that were surrounded by gross slough, provided the nutritional status of the patient was good, anemia was not present, and clinical infection not too active (Fig. 2 A-D).

In addition to these reservations there is another even greater obstacle to the study of the results of any original application to these cases. This is due to the impossibility of keeping the secondary treatment of the cases absolutely uniform. In general, secondary treatments consisted of applications either of vaseline or boric acid ointment or of saline or weak Dakin's solution or by various combinations of these. The time of starting and the frequency of the secondary dressings varied to a large extent according to such uncontrollable factors as the reactions of the patient, the area of the burn, whether general anesthesia was necessary for dressing or not. If an attempt is made to classify the cases according to the sequence and frequency of the various dressings the number in each class becomes so small as to have no statistical value. For this reason no attempt is made

to correlate the effects the various secondary treatments may have on the time of healing. Because of these same factors Tables V and VI are presented as indicating, in only a very limited way, any effects of the primary surface treatment.

TABLE V

STUDY OF 150 BURNS

HEALING OF THIRD DEGREE BURNS, GRAFTED CASES

	F. G. S.—Days			T. F. G.—Days			No. of
	Min.	Max.	Av.	Min.	Max.	Av.	Cases
Small ointment	16	28	24	21	72	33	11
Large ointment	21	60	32	21	120	39	8
All ointment	16	60	27	21	120	36	19
Small tannic-silver	34	36	35	39	44	42	2
Large tannic-silver	36	55	41	43	66	51	4
All tannic-silver	34	55	39	39	66	48	6
Small triple dye	24	38	33	35	62	44	6
Large triple dye	18	60	39	27	119	54	6
All triple dye	18	60	36	27	119	49	12
All small	16	38	28	21	72	38	19
All large	18	60	36	21	120	47	18
Total	16	60	32	21	120	42	37

F. G. S. equals free of gross slough.
T. F. G. equals time of first skin graft.
"Small" burns are 3% or less of surface area.
"Large" burns are 4% or more of surface area.

TABLE VI

STUDY OF 150 BURNS

HEALING OF THIRD DEGREE BURNS WITHOUT GRAFTING

	F. G. S.*—Days			No. of	Healed—Days			No. of
	Min.	Max.	Av.	Cases	Min.	Max.	Av.	Cases
Vas	14	30	20	14	28	72	44	8
T. S.	28	45	35	4	—	—	40	1
T. D.	25	30	28	2	38	64	51	2

*F. G. S. equals free of gross slough.

Table V suggests that areas treated with vaseline became free of slough earlier and shows that they were grafted earlier than areas treated by other methods. It also shows that cases with small areas were free of slough and were grafted earlier than larger cases. This is contrary to the findings of Cannon[24] in regard to the separation of slough. He had to delay the grafting of his most severe case until the 77th day because of various complications. A similar delay for similar reasons occurred in several of the cases in this series that had comparable or larger areas of third degree burn.

Thiersch grafts were applied in all but two instances. In these exceptions Reverdin grafts were employed. The condition of the patient with 45 per cent of surface area involved would not have permitted a Thiersch operation even if enough suitable donor sites could have been found. Sixty-two per cent of the first Thiersch grafts on all cases grafted were fully successful; 14 per cent partially successful; and 24 per cent failed. All areas treated without grafting were necessarily small and usually consisted of

multiple small areas. The smaller number of cases recorded in Table VI, under healing time, is due to the fact that information concerning some cases was secured by letter or telephone and not by direct observation, and such information has not been used. The table shows that in them there was a more marked difference in favor of vaseline so far as the time required for the slough to disappear is concerned, but essentially no difference in the time of final healing. This is to be expected as the latter is dependent on the exact sizes and shapes of areas and possibly on the efficiency of secondary treatment rather than on the original treatment.

Further analysis of the available data permits the following statements to be made:

1. If Tables V and VI were separated into "Cocoanut Grove" cases and other cases, no difference in results would be found.

2. Deep burns became free of slough after a longer interval than burns that barely removed all epithelial elements. This was particularly true if fascia or tendons were involved, as was true in some of the patients with burned hands.

3. Location of the burned area was not as important as in second degree burns although, again, the thick skin of the back was usually slow to separate even when the underlying fascia was not involved.

4. Third degree burns from scalds, although less common, reacted in no way differently from third degree burns of the same size and depth that were caused by other forms of thermal trauma.

SUMMARY AND CONCLUSIONS

1. One hundred and fifty cases of burns have been studied from the point of view of comparing results following surface applications of ointment gauze dressings, tannic acid-silver nitrate, and triple dye.

2. There were two slight clinical infections in 75 patients that had second degree burns only, and none of the 75 patients died.

3. Edema of the face disappeared very rapidly without any application of pressure.

4. Skin healing of second degree burns of all areas except the back, took place a few days earlier if ointment or triple dye were used than if tannic acid was used. Skin healing of second degree burns of the back took place a few days earlier if vaselined gauze or boric acid ointment were used for treatment than if either tannic acid-silver nitrate, or triple dye were used.

5. Skin healing of second degree burns of the face was faster and of the back slower than of all other parts of the body.

6. Fifty-seven patients had mixed second and third degree burns with nine per cent, or less of body area involved in third degree burn. There were 19 instances of clinical infection in these cases, but none were serious. None of these patients died.

7. Eighteen patients with more than ten per cent of surface area involved by a third degree burn either died or were seriously ill before recovery.

8. One patient died from shock at 22 hours following inadequate plasma administration.

9. One patient died at five days with thrombocytopenic purpura, anemia, edema, azotemia, and anuria as complications.

10. The remaining 16 patients demonstrate that patients with 20 per cent, or more, of surface area involved in a third degree burn have a very critical burn. All five patients with 10 or 15 per cent of third degree burns survived, while only three out of eleven with 20 per cent, or larger, areas survived.

11. All the patients who died and many of those who lived with third degree burns of ten per cent area, or more, showed infection, severe loss of weight, and critical metabolic disturbances including azotemia, hypoproteinemia, anemia, and abnormally high losses of nitrogen.

12. The statistics suggest, but do not prove, that vaselined gauze and triple dye treatment were safer for large third degree burns than treatment with tannic acid-silver nitrate.

13. Small third degree burns became free of slough and were grafted earlier than large ones.

14. Areas treated with vaselined gauze became free of slough and were grafted earlier than areas treated with the other two methods.

The authors acknowledge with deep gratitude the enormous labors of the hospital staff, in all grades, and in all departments, and of several other agencies and individuals too numerous to name, without whose help the study of and care of these patients, particularly those from the Cocoanut Grove disaster, could not have been carried out.

BIBLIOGRAPHY

[1] Berkow, S. G.: A Method of Estimating the Extensiveness of Lesions (Burns and Scalds) Based on Surface Area Proportions. Arch. Surg., **8**, 138–148, 1924.

[2] Guides to Therapy for Medical Officers. War Department, TM8–210, March 20, 1942.

[3] Aldrich, R. H.: Superficial Burns; In Mason's "Preoperative and Postoperative Treatment." Philadelphia, 1938, Saunders.

[4] Harkins, H. N.: The Treatment of Burns. Pp. 256 and 259, Baltimore 1942, Thomas.

[5] Cope, O.: The Treatment of Surface Burns. ANNALS OF SURGERY, **117**, 885–893, 1943.

[6] Allen, H. S., and Koch, S. L.: The Treatment of Patients with Severe Burns. Surg. Gynec. and Obst., **74**, 914–924, 1942.

[7] Bunyan, J.: Envelope Method in the Treatment of Burns. Proc. Roy. Soc. Med., **34**, 65–70, 1940.

[8] Levenson, S. M., and Lund, C. C.: Close Fitting Plaster Casts in the Treatment of Burns of the Extremities. J. A. M. A., **123**, 272–277, 1943.

[9] Trueta, J.: Principles and Practice of War Surgery. St. Louis, 1943, Mosby.

[10] Siler, V. E., and Reid, M. R.: Clinical and Experimental Studies with the Koch Method of Treatment of Heat Burns. ANNALS OF SURGERY, **115**, 1115, 1942.

[11] Lund, C. C., Levenson, S. M., and Clowes, G. H. A., Jr.: The Treatment of Shock in Patients from the Cocoanut Grove Disaster. (In preparation).

[12] Lund, C. C., Levenson, S. M., and Taylor, F. H. L.: The Treatment of Burn Shock. (In preparation).

[13] Wells, D. B., Humphrey, H. D., and Coll, J. J.: The Relation of Tannic Acid to the Liver Necrosis Occurring in Burns. N. Eng. Jour. of Med., **226**, 629–635, 1942.

[14] Erb, I. H., Morgan, E. M., and Farmer, A. W.: The Pathology of Burns. ANNALS OF SURGERY, **117**, 234–255, 1943.

[15] Wilson, W. C., MacGregor, A. R., and Stuart, C. P.: The Clinical Course and Pathology of Burns and Scalds under Modern Methods of Treatment. Brit. Jour. of Surg., **25**, 828, 1938.

[16] Lyons, C., Problems of Infection and Chemotherapy. ANNALS OF SURGERY, **117**, 894–902, 1943.

[17] Thomas, J. C., and van don Ende, M.: The Reduction of Dust-borne Bacteria in the Air of Hospital Wards by Liquid Paraffin Treatment of Bedclothes. Brit. Med. Jour., **1**, 953–958, 1941.

[18] Taylor, F. H. L., Levenson, S. M., Davidson, C. S., and Adams, M. A.: Abnormal Nitrogen Metabolism in Patients with Thermal Burns. N. Eng. Jour. of Med. (In press).

[19] Taylor, F. H. L., Levenson, S. M., Davidson, C. S., Browder, N. C., and Lund, C. C.: The Problems of Protein Nutrition in Burned Patients. ANNALS OF SURGERY, **118**, 215–224, August, 1943.

[20] Levenson, S. M., Davidson, C. S., and Taylor, F. H. L.: The Problem of Nutrition and Alimentation in Individuals with Severe Thermal Burns. (In preparation).

[21] Cope, O., Nathanson, I. I., Rourke, G. M., and Wilson, H.: Metabolic Observations. ANNALS OF SURGERY, **117**, 937–958, 1943.

[22] Shen, S. C., and Ham, T. H.: Studies in Destruction of Red Blood Cells. III. Mechanism and Complications of Hemoglobinuria in Patients with Thermal Burns; Spherocytosis and Increased Osmotic Fragility of Erythrocytes. N. Eng. Jour. of Med. (In press).

[23] Davidson, C. S., MacDonald, H., Levenson, S. M., and Taylor, F. H. L.: Studies on the Anemia of Thermal Burns. (In preparation).

[24] Cannon, B.: Procedures in Rehabilitation of the Severely Burned. ANNALS OF SURGERY, **117**, 903, 1943.