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Burns, treatment, complications and repair

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Senior Thesis

B U R N S
Treatment, Complications, and Repair

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INTRODUCTION

This thesis intends to present the treatment, repair, and complications of burns, with emphasis on treatment. By way of introduction, a classification of burns will be given, with a brief description of each degree, and mention of certain pathological findings.

According to Delafield and Prudden (8), a remarkable adaptation to moderate elevations of temperature is possible through the heat-regulating mechanism of the body. The maintenance of like, however, is incompatible with very high temperatures.

Local exposure to both extreme heat and cold induces necrosis and various phases of inflammation of the tissue.

Death may be caused by the inspiration of smoke and flame; by the drinking of hot fluids; by the direct contact of flame or hot substances with the external surface of the body. It may be due to the direct effect of the agents, to secondary affections of the viscera, or to the exhaustion produced by long-continued inflammation and suppuration. Sudden death may occur after extensive burnings of the skin.

It is customary to divide burns into four degrees:
First degree......Erythema of the skin.
Second degree......Formation of vesicles.
Third degree.....Formation of an eschar.
Fourth degree.....Charring of the tissue.

In the first degree burn or the erythematous stage, the only lesions are the reddening of the skin due to the widening of the capillaries under the influence of the irritation, edema of the subcutaneous tissue, and later, separation of the upper layer of epidermis in the form of scales.

The second degree burn, in which vesicles are formed, shows on examination only large or small collections of serum which lie in the upper layers of the skin and push up the epidermis. The basal layers of cells may remain attached to the corium in mild cases. If the fluid is drained off, repair takes place in a short time with the covering of the granulation tissue of the corium by new epithelium, and a return to normal conditions if the burn has not been too deep; otherwise the hair, sweat, and sebaceous follicles may not regenerate and the epidermis may remain thin and smooth, without the rugae which are usually present in the normal skin. The section of such a scar shows that the normal papillary down-growth of the epithelium into the corium has not been regenerated, but the layer of epidermis is very smooth, thin, and of even thickness. Extensive changes of this type are noted only after suppuration has occurred, and not when the serum is absorbed aseptically.
In a third degree burn, that in which an eschar is formed, the upper layers of the skin are actually destroyed by contact with the burning agent, whatever it may be. The microscopic examination of such skin shows on the surface a mass of dead tissue either brownish or blackish, and thrombosed vessels, with great injection of those of the deeper tissues. A very considerable edema separates the connective-tissue fibers of the corium. The area about the eschar usually shows burns of both the first and second degrees. When the necrotic area separates from the healthy tissue, suppuration is likely to take place with local and general sepsis, and the final results may be a deep ulcer with erosion of the larger vessels, thrombosis, and a consequent embolus of the various organs, and, at a later stage, amyloid degeneration of the internal viscera through the suppuration. As soon as the eschar has separated, the wound granulates and forms a dense scar, which may or may not be covered up with epithelium. Whether this occurs or not depends upon the size of the burned area, for the ingrowing epithelium will extend just a certain distance. The scar tissue in the skin causes contractures of various types, even in superficial burns. In every deep burn there is
always a tendency for the tissue to break down and form ulcers later, even after complete epidermization has taken place. Very rarely a squamous-cell epithelioma or a sarcoma may develop in the scar.

The lesions of burns of the fourth degree do not differ essentially from those of the third. The surface of the skin is deeply charred; the lesions extend into the corium or the subcutaneous fatty tissue; and in consequence, the ulceration and scarring, if the subject survive the injury, is much more severe. Recovery depends very largely on the area of the skin involved; where more than half of the body is burned, even to a very slight degree, death is almost certain to occur. It is not possible to produce the appearance of a burn by heat applied to the skin after death.

After death from severe burns there is apt to be congestion of the brain and the thoracic and abdominal viscera. The lymph-nodes and lymphatic tissues throughout the body may be swollen and may become the seat of endothelial-cell proliferation and necrosis. There is usually albuminous degeneration of the liver and kidneys; the spleen is swollen and is the seat of focal necrosis. Focal necrosis in the bone-
marrow has been noted. There may be capillary thromboses, interstitial hemorrhages in the kidney, hemoglobinuria, and leucocytosis. These lesions indicate the presence of toxic substances in the body fluids, and thus the general condition may be regarded as an instance of autointoxication.

Secondary lesions are not infrequent after severe burns. There may be edema of the glottis, pseudomembranous inflammation of the larynx and trachea, pneumonia, ulceration of the duodenum, and pyemia with infarctions in the lungs, liver, spleen, and kidneys, and lesions in the suprarenal capsules.

* * *

* * *
There are various methods used in treating burns, and different technique is often employed in the same treatment, particularly in the tannic acid treatment. Only the more modern methods will be presented in this thesis.

C. C. Robinson (19) discusses the present status of burn therapy in a recent article in which he considers several theories that attempt to explain the changes resulting from the primary burn. He states:

"The profound metabolic disturbances following a severe cutaneous burn have been the subject of extensive laboratory and clinical investigation. While as yet there has been presented no single theory which satisfactorily explains all of the observed changes following the primary burn, several rather reasonable theories have been advanced. Of these, three will be discussed briefly. The reaction of the body to a burn strongly resembles the clinical state described by the term toxemia, which implies the presence in the circulation of some toxic agent. The more serious cases usually present early in the course a clinical picture commonly described by such terms
as shock or exhaustion. There is a profound disturbance of the heat-regulating mechanism and in all probability equally serious interference with many other functions of the body. The theories which have been evolved to explain the phenomena of symptoms following burns may be arranged logically in the following groups: first, those in which interference with a normal function of the skin is considered to be the essential factor in the causation of the phenomena; second, those in which the effects observed are attributed to changes in the blood resulting in altered function; third, those in which the picture is explained on the basis of absorption of a toxic substance in the blood stream. Commenting on the theories of interference with normal function of the skin, many of the older writers have laid great stress upon the disturbance of one or another of the various functions of the skin, namely, respiration, excretion, temperature regulation and sensation. More recent writers are pretty well agreed that they may be a contributing factor but in themselves do not adequately explain the sequence of events which take place.

"The Toxemia Theory. According to Davidson there is certain convincing evidence that suggests the formation at the
site of the burn of a toxic substance the absorption of which is responsible for the constitutional reaction. Some worker has succeeded in isolating from the urine of a burnt patient a substance which was toxic to animals. When parabiosis was established between two animals and one was burned the other showed evidence of toxemia. Another experiment showed that toxemia did not develop in the unburned animal when it was separated from the burned animal for twelve hours but that both animals finally died from toxemia when left united. As to the post-mortem findings, degenerative changes in the liver, spleen, kidneys and bone marrow were found in a series of fatal cases. There was also noted a general edema of the amyloid tissues. The adrenal glands weigh from three to five times the normal and the adrenalin content is absent or low.

"Of the various theories presented, that which attributes the constitutional reaction to absorption of some toxic substance from the burned area is most strongly supported by the available evidence."

The author (19) also presents his views on treatment:

"The problem that presents itself in the treatment of burns falls into the following groups: first, the immediate or
emergency treatment; second, the treatment of shock and toxemia; third, the treatment for replacing lost tissue; fourth, the prevention and repair of contractures.

"No. 1--Except in burns involving small areas of skin all cases should receive hospital care. When the patient is taken to the hospital he should be placed immediately in a warm room and all clothing removed. The primary shock in extensive burns is similar to any surgical shock. There is blunted sensibility, cold, moist skin, subnormal rectal temperature, irregular falling respirations, rapid, thready pulse and a very low blood pressure. Morphine is given in doses adequate to control pain. External heat is applied and fluids are pushed, using hypodermoclysis and proctoclysis. Great care is used in the removal of the clothing as this procedure is oftentimes very shocking. Early blood transfusions have been rather extensively tried. Most writers agree that they can see no advantage of it over injections of glucose and saline solution. Davidson in his writings states that he transfuses on admission any patient with a possible fatal burn. This he advises before the onset of shock. If shock develops, the transfusion is repeated not less than twenty-four hours. Other workers have proposed the rather heroic exsanguination transfusion in which the patient is
bled thoroughly before the transfusion. The patient must be kept warm yet the area of skin involved should not be covered. The necessary temperature may be obtained by the use of various electrical appliances such as lamps, etc. If stimulants are needed, caffeine in from one to three grains dosage is given every one or two hours. The administration of fluid, preferably five per cent glucose in normal saline, is the best method of combating the toxemia and shock. It is good practice to give the first fluid intravenously. The fluid increases the blood volume, decreases the toxemia and brings available energy to the body. Normal saline solution is also administered by rectum. The patient is encouraged to drink water freely.

"Accepting the toxemia theory as the most plausible explanation for the body reaction, the rational manner of combating the toxemia would be some form of local treatment which would prevent absorption of the products of protein decomposition from the site of burn. This might be accomplished by the removal of decomposition mechanically or by baths, by slowing the process of absorption, by the use of vaso-constrictor drugs, and third by causing a local coagulation of all devitalized tissues. According to many writers there is a great deal of
evidence in favor of removing as much of the devitalized tissue as possible in an effort to combat toxemia. Some have even advised to use a general anesthetic or large doses of morphine and then wash the bleeding surface with gasoline. The use of these measures is advocated after the primary period of collapse. It is evident that there are borderline cases in which the vitality of the patient might be taxed to such a degree that an otherwise favorable prognosis might be converted into a fatal case. A number of observers have attempted to obtain the same results by continuous baths. Others have advised as a vaso-constrictor adrenalin in a dilution of one to ten thousands. In the local treatment of burns it is to be remembered that a burn is a wound and the usual antiseptic and aseptic precautions which pertain to all wounds apply to burns. Strong antiseptics are to be avoided. Picric acid lessens pain in a one per cent solution, but poison cases have been reported. An ointment containing butesin and picric acid is very soothing but the writer has seen dermatitis follow its use. The administration of antitetanic serum may be considered in cases which may have been contaminated by dirt after the burn. Numerous applications have been devised whose primary purpose is to allay pain. Carron oil,
equal parts of lime water and linseed oil, may be used but this is usually stale and contaminated. Ambreen is a French preparation of secret formula but constituted chiefly of paraffin and oil of amber. Sherman of Pittsburgh has treated 3,000 cases by the paraffin method and believes it very efficient. The patient is free from pain after the first twenty-four hours in most cases. There is more rapid epithelization in surface burns under paraffin and the scar formation is thought to be less. Sherman emphasizes that paraffin should never be used in a wound harboring necrotic tissue. The wound should first be debrided and, according to Sherman, dried. The paraffin is then applied by spray or brush. The burn is dressed every day."

"Tannic acid is an amorphous powder which is readily soluble in water, glycerine and alcohol, insoluble in ether and chloroform. It precipitates protein. It forms a more or less stable compound with the protein constituents of the body fluid and cells. When applied to a burn surface in dilute solution further penetration into the deeper lying protoplasms is apparently prevented by this action and the true astringent effect appears to be limited exclusively to the most superficial layers of tissue. The precipitated proteins in the surface treated
provide a protective coating against chemical, bacterial and mechanical action as well as against sensory and inflammatory irritation. It was evident to Dr. Davidson that it might be efficacious in precipitating the poisonous materials in burned tissue and thereby in preventing their absorption. While picric acid has some properties in common with tannic acid it is more toxic and takes a stronger solution to act as a coagulant.

"The method of procedure of using tannic acid: As soon as the patient is seen he is given a rather large dose of morphine hypodermically to alleviate the intense pain. A two and one-half per cent fresh aqueous solution of tannic acid may be used as a spray over the burned area. If used as a spray, it should be sprayed on every twenty or thirty minutes until the burned tissue assumes a tan brown color and coagulation takes place, which usually occurs in eighteen to twenty-four hours. As blisters appear they are punctured so as to allow the escape of fluid and tanning of the tissue. The tannic acid not only diminishes the absorption of the toxins but the pain is much decreased in a few hours' time. Another method is to cover with dry sterile gauze pads the burned area and then soak with a two and one-half per cent aqueous solution of tannic acid."
It is essential that tannic acid solution be made up fresh just before its use. As soon as the part is found to have assumed a light brown color all dressings are removed. In order to facilitate the removal of the dressings without pain it has been found desirable to wet the gauze with fresh tannic acid solution. The wound is thereafter left exposed to the air but is carefully protected from chemical injury, chilling and bacterial invasion by a suitable cradle draped with sterile linen. A convenient way of supplying artificial heat is by means of an ordinary electric light bulb within the cradle. Five per cent tannic acid ointment may be used about the eyes."

"In the series of cases which have come under the author's observation treated consistently with tannic acid solution, the toxemia was markedly less than cases treated otherwise.

"The evidence of the reduction in the toxemia; the clinical behavior of the patient; the low temperature curve and the low mortality rate from the primary toxemia were evident. While there was evidence of infection in two cases, they were not severe and saline or Dakin's solution reduced the temperature to normal in two days. Again, in the cases treated by tannic acid the lessening of pain was very striking, some of the
patients complaining of a burning sensation at the beginning but were usually relieved in a half hour after the application of the tannic acid and no further pain was experienced. Narcotics rarely have been used after the first administration. There was a marked diminution in the amount of scarring perhaps due to a decrease of infection, decrease in the amount of irregular granulation and the superficial crust which probably acts as a bridge for the spread of epithelium over the burned area. In most cases there was a clean, dry surface. There is in some cases some exudate which in most instances does not need to be removed, and if no application such as boric acid be applied to soften those crusts the epithelium will grow rapidly under the crusts. In the rather small series of cases coming under observation one is impressed first with the fact that there is less toxemia; that wet dressings, particularly boric acid, will cause a return of toxic symptoms; that tannic acid is an analgesic; that the best results are obtained by not using vaseline dressings prior to the tannic acid; that the open air method causes less toxemia and produces a general comfort. There is evidently a prevention of loss of body fluid. Secondary infection is lessened greatly. Scar formation is less-
ened greatly. Scar formation is less marked. The protective layer of the coagulated protein forms a crust and young epithelium forms over the denuded area."

The authors Hunt and Scott (12) report on a series of sixty-three out-patient cases of minor burns treated with reinforced tannic acid dressings. "The oldest patient in the series was a woman of 73, and the youngest a child of 18 months; the burns have been situated on the face, shoulders, chest, back, arms, legs, hands, and feet, and have varied in size from 2 x 1 1/2 inches to 12 x 6 inches. The majority have been scalds from boiling water, milk, or tea; but high-voltage electric current, molten wax, hydrofluoric acid, salad dressing, and boiling beer have entered the list. The interval between the time of the accident and the commencement of treatment varied from half an hour to ten days.

"The three modifications of the method tried were:
(a) tannic acid in ether reinforced with gauze; (b) tannic acid in ether reinforced with gauze and collodion; (c) tannic acid in water reinforced (on the third day) with collodion.

"(a) Tannic acid in ether reinforced with gauze. Under general or local anaesthesia the area around the burn and the
burned surface itself were cleaned with spirit, blistered skin cut away, and a saturated solution of tannic acid in ether (2½ per cent) painted on with a soft camel-hair brush until a white coagulum formed. A thin layer of gauze was then laid over this so as to overlap its edges, covered with more gauze soaked in the tannic acid solution, and a bandage applied. Two days later the gauze was lifted off, leaving one layer still in contact with the raw area; the edge of this lowest layer was usually black and hard, its centre still yellow and moist. Strips of gauze, soaked in the same solution, were again laid on, the patient being warned that this would be painful for a moment or two. On the fourth and fifth days, if the centre of the gauze was still moist, more of the solution was again used; if dry, only a spirit dressing was needed, and the patient did not attend for a week. On the 12th to the 16th day the layer of gauze peeled off without pain, exposing new pink skin underneath. This was hardened with spirit for two days before all dressings were discarded."

This method was found to be very good "when the burns are extensive and dirty, when oil or grease has been used as a first-aid dressing, or when there has been a delay of more than
twenty-four hours after the accident, for these conditions necessitate thorough cleansing with ether and ether soap, which must be done under an anaesthetic.

"(b) Tannic acid in ether, reinforced with gauze and collodion. Under local or general anaesthesia the burned area and its surroundings were cleaned as before, and painted with tannic acid in ether until a coagulum began to form. To the tannic acid in ether an equal quantity of collodion was then added and the painting continued. Over the coagulum a thin layer of gauze was laid, fixed in position with more of the solution, and, when this was dry, covered with a dressing. Next day all dressings were removed except the lowest layer of gauze, which was now adherent; and more of the mixture painted on—painful for a moment. On the third day this was repeated, usually without pain. After about 14 days the reinforced crust peeled off, leaving a dry, healed surface.

"This second method is satisfactory in clean cases where other circumstances call for an anaesthetic—e.g., in nervous patients and young children. The extra strong crust resulting from the combined effect of gauze and collodion is especially suitable in children, who are always restless and in whom
adequate splintage is difficult.

"(c) Tannic acid in water reinforced, on the third day, with collodion. Without an anaesthetic, the skin around the burn was cleaned with spirit, avoiding the raw area, blisters cut away, and the burn itself carefully painted with a fresh 5 per cent solution of tannic acid in water (grs. 20 of the powder--a level teaspoonful--to an ounce of warm water). This usually caused no additional pain, in fact, when coagulation commenced, what pain there was disappeared; if, by chance, the patient did complain, a weaker solution was used at the beginning. When a white coagulum formed, gauze soaked in the solution was laid over the burn and a bandage applied. Next day the gauze was moistened with the solution and carefully removed, but where the lowest layer was firmly adherent it was left in position. More of the solution was then painted on and allowed to dry before the dressing was replaced. On the third or fourth day the crust was reinforced by painting on collodion mixed with an equal part of tannic acid in ether; if the crust was not dry this was sometimes painful. On the fifth day this was repeated, and in about a fortnight the crust peeled off. If a piece of the crust was separated, as happened not infrequently even when great care
was taken, the authors covered the small raw area with a single layer of gauze and painted it over with the collodion mixture.

"This third method will be found to have the widest application. No anaesthetic is needed, little pain is felt, and it has all the advantages of the tannic acid treatment of severe burns in the wards. By suspending the use of the water solution on the third day, and by strengthening the crust with collodion, the chance of the affected area becoming moist when covered with a dressing is considerably diminished. To what this effect is due is an interesting problem. When the crust is covered with collodion evaporation is diminished, and one would expect more softening than before. In our cases the opposite has occurred, which leaves one to doubt whether evaporation from the surface is as important a factor as was at one time thought. A mild degree of sepsis arising from the edge of the crust where it is rubbed by a dressing and in contact with skin which cannot be quite sterile may perhaps be the sole cause of this softening. When a layer of collodion is added to the crust itself and skin around it, more protection is afforded at the edge, the dressing slides more easily over its surface, mechanical damage to the crust is less likely to occur, and organisms are thus unable to
gain a hold.

"For the treatment of small burns at home the collodion can be omitted, and it is only necessary to cut away the blisters with a clean pair of scissors, to apply a dressing soaked with tannic acid in water, and to change this daily for the first few days. The moist dressing may be changed for a dry one on the second day if all the raw area is covered by a crust; if a piece of the crust is torn off by accident, a moist tannic acid dressing may have to be replaced for twenty-four hours."

Additional considerations are:

"1. In the first-aid treatment of burns and scalds it seems probable that much benefit might result if aqueous tannic acid (5 per cent) were used in every case. The only materials needed would be a small packet of powder (grs. 20) from which a fresh solution is prepared with the greatest ease at a moment's notice, and a strip of clean gauze. Pain would be relieved, the formation of a coagulum ensured without delay, and the chances of sepsis reduced.

"The use of oily substances as first-aid treatment is to be deprecated, because they have to be cleaned away under an anaesthetic before tannic acid is applied. It is said that they
interfere with subsequent tannic acid treatment, but in this se-
ries carron oil, butter, liquid paraffin, and machine oil were
used by different patients before they came to the hospital, and
in every case, after thorough cleansing (under anaesthesia) with
ether, in which these oily substances are soluble, the tannic
acid formed a satisfactory coagulum.

"2. Delay between the accident and commencement of treat-
ment is said to influence adversely the action of tannic acid,
but in this series this fact has not been prominent; after de-
lays of from three to nine days the burns are always infected,
but with thorough cleansing under general anaesthesia, and the
use of tannic acid, many painful dressings have been eliminated
and healing has been rapid.

"3. The degree of the burn or scald is a factor of impor-
tance. First degree burns.....may need no special dressing.
Burns of the second degree, when a blister is formed without in-
volving the dermis, or of the third degree, with partial destruc-
tion of the dermis (leaving the hair follicles intact)--the com-
monest types of burns and scalds--any one of the methods here des-
cribed may be used, the last being most often suitable. Those
of the fourth degree, with the whole dermis destroyed, may be
treated in the same way if small enough to be dealt with in the out-patient department; but in this case treatment is prolonged because a granulating surface is left when the crust comes off at the end of two or three weeks, and this has to be covered in the course of time by epithelium growing from its edge.

"4. Local anaesthesia was employed in nine cases, all small burns 4 x 3 inches in diameter. Four per cent novocain was either injected into the blister, painted on the raw surface, or infiltrated around the burn. It was useful in old persons, and when general anaesthesia was refused when small burns were very dirty and needed thorough cleansing.

"5. A scrubbing brush is often recommended for cleaning up the burned area, but the authors found that those cases healed the quickest which were treated under local anaesthesia, when no scrubbing brush had been used. Much bleeding, such as follows vigorous scrubbing, tends to raise the coagulum above the surface of the burn with the collection of fluid between the two.

"6. It is important that a fresh solution of tannic acid in water should be made up every time it is required, as reduction to gallic acid occurs after a few days.

"7. Solutions stronger than 5 per cent are said to irri-
tate the skin and even to cause sloughing in delicate tissues. A 5 per cent solution has no injurious effect on the burn itself or on the skin around it.

"8. The authors use a soft camel-hair brush ¼ inch wide instead of a spray. If bleeding or serous exudate be free and a spray is used, it is the surface of the blood or serum which is coagulated and fluid collects beneath. With a brush such exudates are wiped away, allowing the tannic acid direct access to the surface of the burn. One brush lasts a long while. After use they are cleaned in ether soap and boiled, stored dry, and before use boiled again. With burns and scalds of the face, the eyes and nostrils have to be carefully protected from tannic acid, and a brush is found to be more convenient than a spray.

"9. Adequate splinting is almost invariably needed for burns involving hands, elbows, and ankles. A plaster-of-Paris bandage, folded on itself to form a 'slab' and fixed with a bandage, is easily applied to limbs of any size or shape.

"10. A great deal of the success of treatment depends on the care with which the second dressing is done. With the larger burns, half an hour or more may be required to remove the gauze, layer by layer, and even thread by thread, when it sticks to the
crust. If handling be rough, this crust may be pulled right off in places, and every precaution should be taken to avoid this. Rather than run this risk, it is often better to leave the lowest layer of gauze in position and to treat it thereafter as part of the crust."

Abraham Strauss (20) gives his views on the treatment of burns in a review of three hundred and fifty-two cases: "The causes of burns may be listed as

Thermal

Dry--such as fire, powder and hot metals.

Moist--as scalds (liquids, molten metals).

Physical

Electrical, sun, x-ray and radium.

Chemical

Burns resulting from explosions introduce a mechanical violence."

"No case of charring . . . survived."

"Investigations have ruled out the theory that death is due to interference with the normal function of the skin and have left us with two theories.

"First, that there is a toxic product absorbed by the
blood from the burned area and that this may be eliminated at least in part through the kidneys."

"The other theory . . . deals with the changes in the composition of the blood. There is a temporary increase in coagulability of the blood but this changes to an incoagulable condition in fatal cases. There is some distortion and fragmentation of the cells and an increase in leukocytes. Further examination reveals an increase in nonprotein and urea nitrogen, a loss in chlorides and sometimes a rise in creatinin and sugar content."

"The severity of the symptoms varies with the intensity of the heat and the size of the area affected. It is usually considered that a second degree burn will be fatal if two-thirds of the body is affected but that only one-third of the body need be burned for a third degree lesion to be fatal."

"Burns of the face, mucous membranes and genitalia always add to the gravity of the case.

"The patient when first seen may be in shock, suffering great pain, restless, chilly with subnormal temperature, rapid feeble pulse, rapid respiration. If the patient is a child, vomiting and convulsions are common. The expression is anxious, the pupils dilated."
"If the patient survives the shock of the first twenty-four hours his course of illness will depend on his resistance and the efficacy of the treatment to overcome the subsequent toxaemia. Nursing is a most important factor in the success or failure of the treatment.

"In this period the temperature starts to rise rapidly to 103 or 104. Pulse and respiration rise with it. This is the time when strenuous nursing is important. Fluids must be pushed to 4,000--6,000 cc. in twenty-four hours for adults and for children in proportion. The urine may contain casts and albumin varying from slight trace to very heavy precipitate and the output may be diminished almost to zero.

"At this time the changes in the blood chemistry above noted take place.

"The temperature, respiration and pulse begin to drop as the toxaemia is overcome. The blood chemistry and urinary output become normal. Unless infection occurs, the patient is on the way to recovery and all that remains is to heal the defects. If the granulating surface is infected septic fever occurs. This may cause gradual inanition and anemia and lead to other complications such as pneumonia, otitis media, or septicaemia
which may or may not prove fatal. Transfusions are often necessary to improve the general condition of the patient under such circumstances."

As to the therapy that is required:

"First, treat the shock and the concentration of the blood by warmth, stimulation, fluids, and morphine for pain. If the patient survives the first twenty-four hours, the temperature will indicate the absorption of toxin by a rise. The output of urine will be diminished and the urine may or may not contain albumin and casts. The blood chemistry will show nitrogen retention."

This is a signal to pour more fluids into the circulation and for that the author has not yet given up the exsanguination transfusion of Robertson and Boyd. "It is well to point out that the only way to bleed an infant or a child is to pass the needle or cannula through the saphenous into the femoral at the fossa ovalis. If this site is destroyed, one must use the jugular. The cubital vein is not sufficient. The early transfusion and exsanguination transfusions may react not only by diluting a circulating toxin but by destroying or binding it to some extent. In that way it may be better than the intravenous glucose. Nevertheless the author has lately added the method of withdrawing some toxins
from the blood and diluting the rest by the continuous venoclysis of 5 per cent glucose."

Strauss believes, as do the previously mentioned authorities, in the use of tannic acid after proper preparation of the skin. He (20) continues:

"If an infection has occurred, the precipitate is removed after applying compresses of warm potassium permanganate of Dakin's solution.

"When the crusts have been removed, attention is directed toward getting the granulations clean enough for skin grafts. If the area is not too large, Thiersch grafts are preferred. The more extensive areas are covered either by Reverdin grafts laid on the surface or by pinhead size Thiersch grafts imbedded in the granulations after the method of Braun.

"The earlier the skin grafting is done the less contraction will be found in the resulting scar. These contractions can not always be prevented but an attempt should always be made to fix the limbs in such a position as will prevent contractions and adhesions. With very extensive burns some form of skin flaps may be necessary to cover the defects.

"Some scars result in keloids which may be troublesome for
months because of itching.

"A late complication not infrequent in an extensive scar from a burn is an indolent ulcer which if untreated may finally change to an epidermoid carcinoma."

"It makes little or no difference in treatment whether the destruction is due to a scald or to dry heat.

"When the skin is scalded it has an ashy hue, a sodden appearance. It is never blackened and the hairs remain untouched. A burn from fire on the contrary causes a blackened dry skin. The hairs are scorched and there is a distinct burnt odor present.

"This report is based on a series of 352 cases treated at Mt. Sinai Hospital, Cleveland, from 1916 to 1931. The largest number occurred between the ages of one and six . . . in this group of 92 cases the females predominate as also in the older patients beyond the age of fifty. In the age groups that include the working ages, industry accounts for the preponderance of males injured by burns. Furthermore the burns are so severe between the ages of one and six that the death rate is 26 per cent, second only to the severe burns in the aged.

"The youngest in this series was seven weeks and the oldest was aged eighty-eight. Nine of the eleven cases under one year
of age were scalds, one was a chemical burn, and one was due to a hot metal plate. Fire which was the predominant agent in all other ages, never was the cause in these infants under one year.

"The complications met with in this series were two cases of tetanus, four of laryngitis, one serum reaction, one scarlet fever, one septicaemia, and three otitis media. Transfusions were resorted to in fifteen cases with six deaths. Exsanguination transfusions were used in nineteen cases. Of the latter there were five deaths. . . . These fourteen that survived may owe their recovery in a great measure to that form of treatment which was used when the patient showed signs of toxic absorption.

"Grafts were used in 27 cases, pedicle flaps were necessary in only two.

"Of the eight autopsies performed, four showed the typical picture of status lymphaticus. It is well recognized that toxemia is one of many conditions regarded as a cause of status lymphaticus, and it is therefore little wonder that this end result should be found at the autopsy of a burned patient.

"It is not possible to quote figures in this series to show whether one form of treatment was better than another be-
cause the records are not complete enough. Furthermore, there is no one fixed method of treatment applicable to all burns.

"However, those who have paid special attention to the burned patient are agreed that 5 per cent tannic acid sprayed on the wounds till a precipitate is formed is the best dressing whether or not it aids in preventing toxic absorption. Another reason for improved results is that more fluids are being introduced into the patient to combat the toxaemia and the concentration of the blood. But ... transfusion with or without exsanguination is an aid that cannot entirely be displaced by infusions."

Blair, Brown, and Hamm (5) give some very interesting points as to the early treatment of burns and the repair of their defects:

"Aside from the care of the patient himself, treatment should compass three objectives; the care of the injured tissues, prevention of secondary damage, and early functional or cosmetic repair." "Prolonged invalidism and disability represent added expenditure with lessened earning power. Any treatment that materially curtails either is a demonstrable economic gain for all concerned."

As is generally accepted by most authorities, the above-
mentioned men (5) believe that any treatment that lessens shock and controls pain is good treatment and is the first treatment to be considered. Then it is well to follow it with tanning rather than the use of unguents. If the burn is not too deep, the early treatment with tannic acid or some other fixative may be all that is necessary, because it relieves pain, and limits both infection and absorption. If the burn has destroyed the full thickness of the skin or more, the authors (5) prefer to rely on the protective and reparative faculties of the live tissues rather than on chemical control of the dead tissues, not only because in these deeper burns the quick may be too deep to be reached by surface application but also because, when successful, complete fixation retards the natural sloughing off of the dead tissues and thus delays the opportunity for surgical repair. "Caring for these wounds without resorting to tanning may require painstaking extra work, but it will be necessary for a shorter time and will win more worthwhile results.

"The fighting forces of the surrounding tissues are aroused, drainage is facilitated, and pain is allayed by warm moist applications; plain water, physiologic solution of sodium chloride or a mild antiseptic may be used, but a hypertonic salt solution
seems to have special virtues. By its use, most burned areas can be made sufficiently clean and the granulations sufficiently firm for grafting, within from three to five weeks. By this time all the damaged tissue except seared tendons and bone will have been spontaneously thrown off and, if the general health has been maintained, a firm scar bed supporting a healthy crop of firm granulations will have formed. The yellow scar base that is found over the area after these granulations have been sliced off makes an ideal bed on which to grow Ollier-Thiersch or thicker split skin grafts." This method of disposing of the burned tissue is a slower process, but the authors believe that it is surer, safer and more conservative of tissue than an immediate debridement, and it can be carried out in the home.

"Patients who have long endured the pain and discomfort of large infected raw surfaces are apt to be intolerant of the dressing of the wounds. Their general health is made still worse by lack of local care, with resultant bedfastness, loss of rest, loss of weight and probably, worst of all, loss of morale; thus, such patients will require for their reclamation time-consuming local and general care and the utmost patience, tempered with morale-restoring firmness. Efficient nursing care may be the
deciding factor in preserving the patient's life."

For these the authors have found that the salt bath alternating with periods of dry heat is the most comfortable treatment. They (5) state: "Children who have lost their entire control at the thought of a dressing have been restored by two or three hours a day in the bath. When out of the bath, they are kept in bed without dressings under a warm tent, heated by electric light globes overhead."

"The hypertonic salt bath: The tube is padded and has supports for the head and feet. The bath is kept comfortable by frequent additions of or a continual flow of warm water, and up to 5 per cent sodium chloride may be added. Cleanliness is important, but no attempt is made at sterility. For adults the large hydrotherapy tube (used for neurologic patients) with a canvas sling in which the patient lies, with arms and legs free, is ideal but not necessary. When a fatal outcome is expected, this method of care is one of the most comfortable and may be continual. If the patient cannot be moved about easily, both the bowel and the bladder content may be passed into the tub, cleaned out, and fresh saline solution added. For patients who are first seen with badly matted and stuck dressings and clothing (and who are often unapproachable),
soaking in the bath is probably the best, quickest and least painful method of loosening the dressings and crusts. The clothes and dressings may be cut away with the patient still in the bath. Active mechanical cleansing of the wound should be done at the time of each bath, and in this way the area may soon be as free of debris as though an immediate deep debridement had been done.

...Some one should be in constant attendance for children."

"The method of using dry heat and no dressing: Electric lights supply warmth. By having them placed high and spreading the sheets over the whole bed, easy access to the patient can be had by the nurses, and the patient has as much freedom of movement as any one in bed. The lights may be placed across the top of a Balkan frame or a special frame may be made to fit adults' or children's beds. If there is much infection and crusting, the patient may be put on a Bradford frame, which is elevated to allow irrigating fluid to run off through the rubber sheet over the end of the bed into the bucket. Every hour or so from 500 to 1,000 cc. of saline solution is poured over the patient. Surgical solution of chlorinated soda, acriflavine hydrochloride, hexylresorcinol, or any other desired antiseptic may be applied on loose gauze dressings. Any adherent gauze is left in place
to be soaked loose in the next bath.

"The patient is left free of tractions or restraints."

Traction aimed at prevention of scar contraction, as usually applied, is practically useless, is very discomforting, and is, the authors (5) believe, a mistaken aim. "Normal active full range movements are encouraged (and rewarded) and in this way many secondary contractures may be overcome or avoided, even though there may be severe contracture in the burned area. If the finger nails are kept short and clean, there is not much damage done by the picking of the wounds and crests that the children are apt to do. The change of treatment each day is good for the patient's morale and, as soon as possible, the burned areas are covered with the water-soluble jelly containing from 2 to 5 per cent sodium chloride on gauze, so that the patient may be up and around. This is left on until the following morning, when it is soaked loose in the bath. This tent arrangement of the bed may be used for practically all badly burned patients, if the wounds are to be left open as in the tannic acid treatment. In many instances the use of the salt bath and dry heat may suffice for the original care of the burn."

"Interest in visitors and playmates is encouraged and,
as soon as a dressing can be borne, arrangements are made for
the patient to be out of bed, if only for a short period, each
day. Wet dressings are preferred, but they are sometimes pain-
ful. Lint or cotton next to the wound may be a happy substitute
for gauze. Each dressing is left on to be soaked loose in the
next bath.

"It may be a problem to get a dressing comfortable enough
to allow some patients to be out of bed at all." The authors (5)
have used as a dressing a water-soluble jelly, to which has been
added from 2 to 5 per cent sodium chloride; this has proved satis-
factory in many cases. "The jelly is applied as any grease dress-
ing but has somewhat the effect of a wet dressing on the granu-
lations.

"In the later period grease might be the most comfortable,
and for areas that do not require grafting there is little objec-
tion to its use at this time." However, grease does not promote
the healthiest type of granulations, and the authors (5) have
found that it is definitely detrimental to the chances of the
"take" of a skin graft if it has been used over a granulating
surface shortly before the application of the graft.

The authors' (5) aim is to keep the wound relatively clean,
to make the patient comfortable, allowing him to move about so as actively to resist secondary contractures, and to repair the surface defect early before the new formed tissues are converted into resisting scar. "If the latter is not practicable, it will be necessary later to remove the contraction of the scar down to its elastic deeper part, thus releasing all distortions and permitting the wound to expand to its original size before either free grafts or flaps are applied.

"Soon after the burn it may be impossible to differentiate between partial and full thickness destruction of the skin, and this is one reason against immediate deep debridement. Where any of the epithelial elements have been left, there will be spontaneous healing with a very serviceable skin; however, the surface may be red and thick for a long time, may eventually become glazed, and, in the Negro, it may be white. This spontaneous repair may account for the healing of many apparently deep burns, with little scarring, under almost any, or no plan of treatment.

"Where there has been a loss of the full thickness derma, spontaneous healing occurs by an extension of epithelium from the sides, thus covering granulations that are converted into scar.
This, however, is not a normal habitat for epithelium nor is it a well established tissue, the result being that the larger surfaces may break down with any irritation; and this is especially likely to happen with any temporary lowering of the general tone. For some time after healing it may be possible to denude the newly epitheliated scar surface by rather light pressure of the thumb. The reason for this instability can be clearly shown microscopically. The epithelium lies directly on a scar base made up of fibers that are arranged chiefly parallel with the surface. This scar tissue base may be of excessive thickness and have a poor blood supply. The epithelial cells extend across in a plane, only a few cells thick and with very few papillae. Normal derma is not present to support the cells or attach them to the subcutaneous tissues.

"Neither the hair follicles and their sebaceous glands nor the sudoriferous glands are regenerated, though remnants of any of these may persist, buried deep in the substance of even old scars, and subsequently be the cause of recurrent local inflammations. The ingrowing epithelium may be but a few layers of cells thick in one area and close by may show marked hyperkeratosis. This keratosis and a dryness of the surface may be
the direct result of lack of normal gland secretion. The resistance of such a surface increases with the passage of time, and the deep scar may become less thick and softer, but nearly always some deformity is left and occasionally there may be late malignant change, especially if the epithelium has been subject to trauma or irritation or has been repeatedly cracked open. The contraction in the scar area that occurs while spontaneous epithelization is being awaited may cause serious fixation of joints, a distortion of bone and joints, or deformity of any involved part of the body such as the hands, jaws, face, neck or trunk.

"The early application of thick split skin grafts to the granulating areas, where full thickness of the skin has been lost, will give quick healing and usually quite satisfactory appearance and surface protection."

In judging the proper time to make the repair in the individual case, the authors (5) are guided by the condition and morale of the patient, by the age and appearance of the granulations, by the character of their discharge, and possible other local factors. When these all appear to be satisfactory, the authors have no more curiosity about the number or character of
the contained bacteria than they would have about the preoperative bacterial content of a healthy mouth in a healthy individual. "Conversely, as long as any of the factors named in the first group remain distinctly adverse, absolute sterility of the field would likely not be a sufficient warrant for proceeding with the repair.

"The grafted area will contract some; this is part of the healing process. The thicker the graft used, the less will be the contraction; but even under thick pedicle flaps there is always some narrowing of the area. Under a full thickness skin graft the subsequent contraction is greater than under a pedicle flap, similarly circumstanced, while a defect covered by a split graft may contract 60 per cent or more of its original size if there is no resisting tension. However, the early closure of granulating defects with pedicle flaps is not often advisable; and while full thickness grafts make better repairs than split grafts, their growth on anything but a sterile field is too uncertain to warrant their use in the presence of even a mild infection.

"Where appropriate, thick split skin grafts are used in preference to the full thickness grafts, because of the greater
assurance of their 'take', the shorter time necessary for the operation and for healing, and the lesser deformity of the donor area. Such grafts may be cut almost full thickness if desired, but even the thinner ones have enough derma to give the needed anchorage that is lacking in spontaneous epithelization of a defect.  

"In its final stage this graft may be whiter or more pigmented than the surrounding natural skin. In any case, the natural clearness characteristic of even very pale normal skin may be decreased or absent. This seems to be an essential fault in the results of free skin grafting, less marked with the full thickness graft than with the split graft. On an exposed surface, especially the face and neck, this may materially detract from an otherwise successful result, but this can be helped by the application of cosmetics, which shiny scar epithelium will not hold.

"When patients present themselves with healed deformities, it is necessary to determine the extent of the original loss and the tissues available for the possible repair. To overcome the deformity complete relaxation of the displaced tissues must be attained by the removal of binding scars, and the resulting raw
surfaces must be covered with tissue of suitable thickness.

"For widespread burned areas that need the release of deformity and covering of raw surfaces, the thick split graft is not only applicable but frequently the only one available, because the use of full thickness grafts would leave too much surface defect (or scar) in the donor areas. If the patient is in a satisfactory physical condition, very wide areas may be grafted at one time and the economic value in reduced hospital time and early return to occupation is high. After some months, in many instances, these grafts are found to be practically indistinguishable from full thickness grafts. . . . Full thickness grafts are used when the best possible early bearing surface and cosmetic result is desired, unless it is necessary to use pedicle flaps."

A. J. Bettman (4) in expressing his views on burn therapy states:

"The burning of living tissue develops a soluble substance which when absorbed has a toxic effect on the animal organism.

"When tannic acid solution is applied to burned tissues they are leatherized, tanned. The soluble protein is precip-
itated and changed into non-suluble protein which is not absorbed. Also the raw surfaces are covered by a firm coating which acts as a protection. Tannic acid solution is easy to apply and there are no painful dressings to be removed.

"The local treatment of every burn should be considered an emergency, as what is done in the first few hours may determine the final outcome. The solution should be applied early.

"The tannic acid solution may be applied by soaking sterile gauze with preferably 5 per cent solution of tannic acid, placed on the burned area and kept moist, or it may be applied directly to the burned area with an atomizer. In either case it should be applied every ten to fifteen minutes for the first few hours, then every hour until the tanning is complete, which should be within eighteen hours. Eight teaspoonfuls in a glass of water makes approximately a 5 per cent solution. Any oils or ointments previously applied must be removed before the tannic acid can reach the tissues. Carron oil is only mentioned to be condemned, it was justifiable in its day but with the proved superiority of tannic acid solution it should not be used.

"As soon as the burned area is completely leatherized it takes on a brown color. The dressings should then be removed
and the area exposed to the air to dry, protected from injury, chilling, and infection. A tent placed over the area with electric bulbs gives an adequate source of heat. The importance of drying the crusts should not be overlooked. When they remain dry the temperature, pulse, and white blood count early tend to become normal. When the burns are deep the coagulum dries slowly and there may be some toxemia for absorption takes place where there is moisture. If the coagulum is not thoroughly dry in six to eight days, and the temperature, pulse, and white blood count become elevated and malaise and delirium appear, the leatherized tissue must be removed promptly, surgically, softening with Dakin's solution or petrolatum if necessary.

"Following burns the temperature usually rises during the first twenty-four hours then drops to normal or slightly above. When the crusts are properly tanned and dried the temperature remains just above normal until the crusts are removed which is about the third or fourth day in superficial burns and about two weeks in deeper burns. The toxic stage is usually over in forty-eight hours when the tanning is started promptly.

"As a result of an extensive burn there is an outpouring of body fluids with a concentration of hemoglobin and
other blood elements. It is to overcome this concentration that fluids are necessary. Fluids should be administered in large quantities by mouth, rectum, and by hyperdermoclysis if necessary. One thousand cc. or more of fluids per twenty-five pounds body weight should be given. Dehydration must be overcome.

"Fluids should not be forced in every burned case. In the patient who has inhaled flame, edema of the glottis should be looked for. When the body burn is small and the patient has inhaled flame, the patient should be dehydrated by giving twenty-five cc. of 50 per cent glucose intravenously, or an ounce of concentrated solution of magnesium sulphate by rectum. The edema of the glottis may be a death dealing complication if not watched for. A trachiotomy may be necessary.

"Deaths which occur during the first twenty-four hours are usually due to the large area of skin burned which overwhels the patient. During the second twenty-four hours the number of deaths has been reduced since the introduction of tannic acid treatment. The late deaths have also been reduced due to control of infection and septic complications.

"Glover, reciting his own results and those of other surgeons, gives figures which show an average death rate of 13
per cent following tannic acid treatment. In his own series of 310 cases treated in six years the death rate was 9.6 per cent. No cases treated by this method were lost on the sixth day or later following the burn and in the earlier days the death rate was considerably below those treated by other methods except the deaths which occurred on the first day.

"The extent and depth of the burn cannot always be determined at the outset and it is therefore important to see that the tannic acid solution reaches into the deep layers. Blebs should be punctured and the skin forming them should be taken away immediately. Foreign material should be removed without added trauma.

"Cardiac deaths may occur on the fourth or fifth day or earlier. The heart should therefore be watched carefully, especially where a heart lesion existed before the burn occurred. Supportive measures may be indicated throughout. Cardiac deaths following burns similate late cardiac deaths in diphtheria. Apathy, pallor, rising pulse rate, bradycardia, heart irregularity, vomiting, pulmonary edema precede coma and death.

"Late complications in burns, according to Bettman (4), may be peptic ulcer, acute colangitis, acute cystitis, acute
polyarthritis, peripheral neuritis, retinitis, and other conditions resulting from local sepsis.

"As soon as the coagulum crust is removed everything possible should be done to promote epithelization so as to prevent the profound secondary anemia which so often develops. As a general rule skin grafting should be done promptly, where large areas are devoid of epithelium.

"Tannic acid treatment does not influence epithelization but through its use secondary infection is less likely to delay healing.

"In second degree burns the crust often may be left on until displaced by the new epithelium growing beneath."

From the work of P. Lamariee (13), we find that he has treated about 2,000 patients since January, 1938, using ultraviolet light. These patients had wounds and burns. In all cases cicatrization was more rapid than after the usual treatment and the cicatrix was soft and painless.

"After much experimentation it was finally decided to use large doses especially for atonic wounds. The wound was cleaned and was irradiated at a distance of 30 cm. from the arc for 10 to 15 minutes every day and in many cases twice a day. A non-
adhesive dressing was applied during the intervals between treatments. The irradiation was not absolutely local but usually an entire segment of the limb was exposed. No erythema or burns were noted although certain precautions were taken when the wound was in a region where the skin is sensitive such as the neck, abdomen or back. When cicatrization was well started the frequency or the length of the irradiations was reduced except where there was an important loss of substance. In such cases the large doses were continued.

"Ultraviolet light has a bactericidal effect and it increases the circulation thus producing a better local defense."

"It was found that by not only irradiating the wound but also a segment of the extremity, general reactions of the organism were produced with a corresponding improvement in the general condition. The tonus of the organism was increased and patients with gynecological conditions showed a definite improvement."
SUMMARY

We may accept the toxemia theory as the most plausible explanation for the changes observed following the primary burn. However, this theory is not accepted as the explanatory theory, but from certain experiments which have been reported by workers, and from many observations made, it no doubt presents facts which are to be duly considered.

Even after such experiments and observations, no single definite method of treatment applicable to all burns has been accepted. However, it is generally conceded that a five per cent solution of tannic acid sprayed on the wound till a precipitate forms, is an excellent dressing, regardless of its recognized value in preventing toxic absorption. Fluids are being forced into the circulatory system to a greater degree, to combat toxemia. This is usually adequately done by intravenous injection of five per cent glucose or normal saline solution in severe cases when fluids by mouth are not sufficient.

The onset of complications, following the primary burn, usually depends upon the proper treatment and careful nursing at the time of the accident and for some time following.
Proper repair will nearly always be a result of proper treatment, although this repair, in a good number of cases, will need to be aided by skin grafting. The pinch graft is most commonly used.
CONCLUSION

In conclusion, since one method of treatment cannot be applied to every burn case, a method suitable to each individual case must be selected, after the necessary emergency treatment has been administered.

The value in using tannic acid is well established.

The later treatment is governed by the extent of the burn. The purpose is to reduce the possible permanent disabilities.
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