1947

Early treatment of thermal burns

Charles William Broders
University of Nebraska Medical Center

THE

EARLY TREATMENT

OF

THERMAL BURNS

Charles William Broders

SENIOR THESIS

presented

to

THE COLLEGE OF MEDICINE

UNIVERSITY OF NEBRASKA

Omaha, Nebraska

1947

TABLE OF CONTENTS

TABLE OF CONTENTS

(Continued)

TABLE OF CONTENTS

(Continued)

INTRODUCTION

There probably has never been any greater source of suffering to mankind than that which has been inflicted by burns.

Barnes (1933) remarks: "It is said in Grecian mythology that man was the last race created, and in consequence thereof was the most poorly endowed with physical gifts. So Prometheus stole fire from the hearthstone of the gods on Mount Olympus and bestowed it as a gift which would set man apart from all other animals. And so it has. But the sword with which civilization was founded is two-edged, and since time immemorial the followers of Aesculopius have sought to bring relief to those luckless mortals who have felt its bite."

The trail of pain, mutilation, and death left by fire attests to the validity of the above quotation. It is also true that even in this modern era physicians are still confronted with the problem of how to care for those unfortunate victims of fire.

In the beginning of the present century, Biddle (1901) exclaimed, "How glad we ought to be for the merciful provision of nature which renders the prolongation of life impossible under the torture of a very extensive burn."

Fortunately, the medical profession of today can afford to be more optimistic because it is meeting the challenge offered by burns. Controversies over the methods of burn therapy still exist, but these serve as healthy stimulants in the continuous search for the final and correct solution. In recent years, World War II has acted as one of the greatest inciters for the improvement in burn therapy. The era of treating only the burned area itself and neglecting the systemic pathology is a thing of the past. Burns are now recognized as emergency injuries requiring the immediate attention of trained personnel.

It is the purpose of this thesis to review these emergency measures used in treating thermal burns. This discussion, therefore, will include the treatment of thermal burns from the time the patient is first seen up to the time that the healing of the burn is in evidence and the patient is on a safe road to recovery. The plastic repair of burns is not an emergency measure, so does not come under consideration in this discussion. For the same reason, the complications seen in the later stages of burns will not be emphasized.

The literature on the local treatment of thermal burns contains many different methods of therapy, but I have preferred to present only the more commonly used treatments because it is these that have given rise to more disagreement and therefore are more interesting. As to the systemic treatment, the authorities are more in accord as to what treatment should be used, so that the main stress will be upon the various techniques practiced.

No discussion of treatment would be considered complete without including the rationale behind it. To meet this demand, I have included in this paper a brief explanation of the pathology and physiology involved in thermal burns.

HISTORICAL REVIEW

The art of treating burns is known to have dated back as early as the year 430 B. C. at which time Hippocrates was practicing medicine. His is one of the earliest records of burn therapy. Hippocrates' suggestion (quoted from Biddle, 1901) for the local treatment of burns was: "You must boil the tender roots of the ilex, and if their back be very thick and green, it must be cut into small parts, and having poured in white wine, boil upon a gentle fire until it appears to you to be of the proper consistency so as to be used as a liniment, and it may be prepared in water after the same manner. Another, not corrosive; old swine's seam is to be rubbed in by itself, and it is to be melted along with squill, the root of which is to be divided and applied with a bandage. Next day it is to be fomented; and having melted the swine's seam and wax and mixed them with oil, frankincense and shavings of lotus and vermilion, this is to be used as liniment. Having boiled the leaves of the wakerobin in wine and oil, apply a bandage."

Even at the beginning of 1800, according to Barnes (1933), physicians were not so far away from the use of lard and the aromatic oils of Hippocrates.

The first radical change in the local treatment of burns appeared in the literature in 1867 when Pirrie (1867) advocated the use of phenol after having heard Lister present a paper on its antiseptic value. But Barnes (1933) says that it wasn't until the beginning of the present century that strict surgical cleanliness received the endorsement it deserved, as most burns were covered with some grease before the patient was taken to a physician for treatment, thereby making it virtually impossible to have primary antisepsis.

Biddle's (1901) recommendations for treating shock were the following: "Strychnine, digitalis, whisky and aromatic spirits of ammonia should be administered in full doses, with a generous, quickly and easily assimilating diet. Morphine in one-fourth grain doses or codeine in one-half grain doses or twenty grains of bromide of potassium, with five grains of chloral hydrate, are given frequently enough to control delirium, allay pain and procure rest and sleep." For the local application, he applied a mixture of lead carbonate, powdered acacia, sodium bicarbonate, and linseed oil "made thin enough so as to spread nicely upon canton flannel."

The mortality from burns remained high and the treatment remained essentially the same as it had for centuries until about twenty years ago when the modern medical world began to offer new hope for the burned patient.

GENERAL CONSIDERATIONS IN TREATMENT

Burns, like other types of injuries, reflect the benefits of prompt, correct, and sufficient treatment.

Conklin (1945) has proposed that the general treatment program for burns be divided up into three phases: namely, the first or immediate phase, the second or post-shock phase, and the third or hospital phase.

Harkins (1945b) has devised a similar type of program consisting of three phases, but has made it more clinical. He classifies the phases as follows:

I. Phase of hemoconcentration.

This is the earliest phase and consists of the first two or three days after the burn is received. He states that it is during this period that at least sixty per cent of burn deaths occur. The most important part of therapy during this time is the prevention or the treatment of shock. The early relief of pain is also essential. Another important consideration is the prevention of plasma leakage at the site of the burned area. Adequate local care helps to reduce or stop the plasma loss, and thereby, decreases the tendency for the patient to go into shock.

Conklin (1945) stresses the importance of avoiding contamination of the burned area. Bodenham and Brisk (1943) showed that immediately after the burn is received the burned area is sterile because the dead skin forms a protective layer over the burn. However, if not prevented, contamination will occur early from the unburned skin surrounding the burn, from clothes and from the respiratory tracts of both the patient and the attending personnel.

II. Phase of toxemia and sepsis.

This phase includes the period from the third to the tenth day or longer after the burn is incurred. During this time deaths which occur may be due to liver necrosis, anuria, sepsis, or other toxic factors.

III. Phase of healing.

This is the period of anemia, hypoproteinemia, avitaminosis, and sepsis. This phase occurs from the second week usually to the time that the last granulating surface is completed. Deaths during this time result from debilitation or sepsis. The most important therapeutic consideration at this stage is one of maintaining nutrition.

In retrospect, it is the general consensus of opinion among the authorities of today who have had experience in treating thermal burns that treatment should be directed toward the following aims:

1. Relieving pain.
2. Preventing shock.
3. Preventing infection.
4. Preventing toxemia.
5. Stimulating epithelization.

A discussion of each of these salient points will now be considered in the subsequent chapters.

CLASSIFICATION OF BURNS

A burn, as defined by Pack and Davis (1946) is "an injury inflicted on the body by a degree of heat higher than is compatible with healthy action in the part affected."

There have originated over a period of many generations various methods for classifying burns, but there is none that has been accepted by the medical profession so wholeheartedly as that developed by Dupuytren early in the nineteenth century. Dupuytren's classification (quoted by Pack, 1936) which is based on clinical appearance of the burn, is summarized as follows:

First Degree Burn: There is erythema or reddening of the burned area. There may be some loss of the superficial epithelium in a day or two following the subsidence of the hyperemia.

Second Degree Burn: There is formed vesicles which are filled with serum. The base of the vesicles is usually just above the germinal layer of the epidermis. In this degree of burn, healing occurs from many points over the surface and from the edges of the burned area.

Third Degree Burn: There is destruction of large thickness of the epidermis, and the exposure of the papillary layers of the derma. Some of the interpapillary epithelium, hair follicles, and sebaceous and sweat glands are unaffected. The burned area is necrotic and is surrounded by a zone of secondary inflammation which gradually fades out into the normal surrounding epidermis.

Fourth Degree Burn: There is destruction of the entire integument and part of the subcutaneous tissue. No hair follicles, glands, or papillae are left intact.

Fifth and Sixth Degree Burns: There is encroachment on muscles and charring of the deep structures with thrombosis of the vessels and destruction of the vessels' walls.

The classification of burns by degree is used in this country today with some slight modification. The tendency now is to include fourth, fifth, and sixth degree burns under third degree burns, thus utilizing only three degrees of burns.

Dingwall (1943) has designed a chemical test for distinguishing between second and third degree burns. He gives 10 cc. of a 20% solution of sodium fluorescein intravenously and then views the burned area under an ultraviolet light screened with a Wood filter. Second degree burns have a yellow-green appearance and third degree burns have a black color. Although his method is rarely used, it can serve as an aid in deciding whether or not to debride a burned area in which there is some question as to whether the tissue is viable or not. His assumption is that a "black" area is dead tissue, and a "yellow-green" area is possibly viable.

Maguire (1945) believes that the degree of a burn is an index of the amount of scarring, contracture, and disability to be anticipated later. He feels that second and third degree burns should be considered together, since in extensive burns there are some elements of both types present in varying extents.

A very simple classification has been proposed by Goldblatt (1927). This author groups burns under either first degree burns, or under second degree burns. Under the former, he includes a burn which heals without scarring and is characterized by erythema or vesicle formation. Under the latter, he classifies those burns which heal by the formation of scar tissue and contractures. This includes all other burns of a more severe nature.

Maguire (1945) classifies burns according to etiology as follows:

A. Thermal Burns.

1. Dry heat--exposure to actual flame.
2. Moist heat--exposure to boiling liquids, live steam, etc.--known as scalds.

B. Electrical Burns.

1. Caused by electric currents.
2. Caused by x-ray or radium.

C. Chemical Burns.

1. Caused by contact with strong acids or alkalies.

One of the more recent methods of classifying burns is that presented by Berkow (1924) in which the percentage of body surface is estimated. It has been found to be of immense value in determining the amount of plasma dosage for a burned patient and in predicting the prognosis. He has worked out the percentage of surface area of various parts of the body and has found the following percentages to be the average for a seventy kilogram adult.

Head	6%
Total surface of upper extremity	18%
Anterior surface of trunk	20%
Posterior surface of trunk	18%
Total surface of both hands	4%
Palm of hand	1%
Total surface of both thighs	19%
Total surface of lower extremities	38%
Total surface of both legs	13%
Total surface of both feet	6%

Children's proportions are not the same as for adults, so he has made the following modifications:

Trunk	40%
Upper extremity	17%

For children the proportions can be determined from the adult standards by applying the following formula: For burns of the head and lower extremities, subtract the child's age in years from twelve and add the remainder to the number expressing the adult proportion of the head (6%) and subtract the same amount from the number expressing the adult proportion of the lower extremity (38%).

In order to estimate a lesion of the head, trunk, upper or lower extremities, the number expressing the proportion of that part is multiplied by the fraction expressing the relation of the lesion to the part. He gives the following fractions of the different parts:

Hand	1/4 upper extremity.
Arm	3/4 upper extremity.
Foot	1/6 lower extremity.
Leg	2/6 lower extremity.
Thigh	1/2 lower extremity.

The trunk includes the neck, and the lower extremities include the buttocks.

Aside from the other factors such as the age and the sex of the patient, the prognosis depends upon the degree of depth of the burn and the percentage of the surface affected. Pack (1946) believes that the depth is not relatively so important as the extent of the surface involved. All burns covering one-third of the body surface are extremely serious if not immediately fatal. He has found that burns of the face, abdomen, and genitalia cause symptoms and dangers far out of proportion to their area allotment.

TREATMENT OF PAIN

One of the first and formost points to be considered in the therapy of thermal burns is the obtunding of the severe, agonizing pain. As will be shown, pain is one of the several factors that causes the patient to go into a state of shock. Thus, the relieving of pain accomplishes two things: it relieves the victim from the unbearable torture, and it helps to prevent shock.

Morphine has long been regarded as the drug of choice for relieving severe pain. Lundy (1944) advocates the giving of morphine intravenously because this method produces the quickest relief and is the most accurate method of determining the dose. The reactions to the morphine are evidenced by a prompt relief of pain and by a contraction of the pupils. He has found that most persons suffering pain will tolerate morphine in a large dose even up to the point where the pupils are almost pinpoint. McLaughlin (1946) also advocates the intravenous administration of morphine and explains the rationale of this method on the fact that when the patient is in shock or impending shock the peripheral blood capillaries are in a state of collapse. Therefore, if the morphine is given subcutaneously or intramuscularly, none of the drug would be absorbed, or at the most, it would be absorbed very slowly and the patient would not be relieved of his pain. This frequently results in the administration of more morphine in a vain attempt to relieve the patient. The morphine remains at the site of injection until the patient is brought out of shock. When this occurs, the peripheral capillaries dilate, the morphine is absorbed, and the patient is then thrown into respiratory failure due to absorption of an overwhelming dose.

Both authors recommend that the dose be 1/4 grain initially, followed by another 1/4 grain of morphine in ten to fifteen minutes if necessary. Subsequent doses administered may be smaller than 1/4 grain, depending upon the size of the patient and the amount of relief from pain which the patient experiences after the first dose or two.

Ackman, Gerrie, Pritchard, and Mills (1944) recommend the giving of 1/4 grain of morphine hypodermically if the patient is not in shock, but if the patient is in shock, they give the dose intravenously.

Pack and Davis (1946) like to give morphine and atropine together if the pain is marked.

The application of ointments, pressure dressings, and other agents are also helpful in relieving the pain, but these will be discussed more fully in the chapter on the local treatment of burns.

SHOCK

The part that shock plays in burns has gained widespread emphasis during the past ten years. The remarkable improvements in treating burned patients may be directly attributed to the increased understanding of the physio-chemical changes that occur in the body during shock.

The importance of treating shock early can be readily appreciated since, as stated by Ferguson (1945), sixty to seventy-five per cent of the fatalities in burned patients and practically all of the deaths which occur in the first two or three days after the burn is received can be attributed to shock. The prompt attention to shock determines in most cases of major burns whether the patient has a chance of survival.

Ferguson (1945) believes that the development and the severity of shock are dependent more upon the involved surface area than upon the depth or degree of the burn. He has also found that shock is produced more rapidly in burns of the face, abdomen, and genitalia than in burns of other areas.

There has been some disagreement as to what differentiates a minor burn from a major one. It is important to realize that in major burns shock is one of the earliest and severest manifestations, while in minor burns, shock, although rarely encountered, may be overlooked. Lepage (1945) states that a painful second degree minor burn is able to and frequently does produce a mild state of shock which should be treated like shock found in any major burn. He considers a minor burn as one in which less than one-fifth of the body area is involved.

Morani (1945) also believes that the clinical course of a burn depends more upon the extent of the surface involved than upon the depth. He considers an extensive burn as one involving over fifteen per cent of the body surface. Anything over this percentage produces a general reaction, the chief of which is shock, while minor burns cause only local reactions and therefore require only local treatment.

The clinical manifestations of shock are described clearly by Maguire (1945) who says that the patient may be restless and anxious, or dull and apathetic. The skin is pale, greyish in color, and the skin is cold and moist. The pulse is rapid and has a low volume. The blood pressure is low, and the temperature is subnormal. Prioleau (1937) adds to the clinical picture of shock by saying that the patient is prostrated, has cold extremities, sunken eyes, and pinched facies.

Shock resulting from burns is generally regarded as consisting of two phases: primary shock and secondary shock. Primary shock or psychic shock is the first phase encountered. Ferguson (1945) believes that primary shock is a psychic one resulting from the pain, fright, apprehension, and frantic overexertion which goes with the production of the burn. He states that in severe burns, especially in those cases where the burning continues over a long period of time, this factor alone may be enough to cause fatal shock. It varies somewhat with the temperament of the patient. Berkow (1943) likewise believes that primary shock is caused by a psychogenic or neurogenic factor. Prioleau (1937) states that it is characterized by syncope, resulting from a vasomotor disturbance.

Secondary shock closely follows primary shock or may even overlap it. Most authorities, of whom may be mentioned Ferguson (1945), Harkins (1945d), Berkow (1943), agree that secondary shock is initiated by the loss of blood plasma from the circulating blood at the burned area. This loss of blood plasma results from an increased capillary permeability. Ferguson (1945) states that a relatively small amount of the plasma is lost in the blister fluid and on the burned surface. He finds most of the loss to be into the tissues in and for some distance around the burned area.

Harkins (1945d) states that as a result of the loss of the extracellular fluid which includes salts and plasma proteins, both into the burned area itself and as a discharge from any denuded surface, there will be dehydration, a decrease in the circulating plasma volume and a relative hemoconcentration of the blood. Ferguson (1945) remarks that because the fluid loss leads to more marked hemoconcentration, oxygen transport of the blood is sluggish and less efficient, and that probably anoxia to the tissues brings about increased capillary permeability in parts of the body away from the burned area.

Dr. A. L. Bennett of the University of Nebraska, College of Medicine, has constructed a graph showing the physiological changes which occur in the shock syndrome. With his permission, I have included it here because it presents a very simple means of showing the over-all picture of shock.

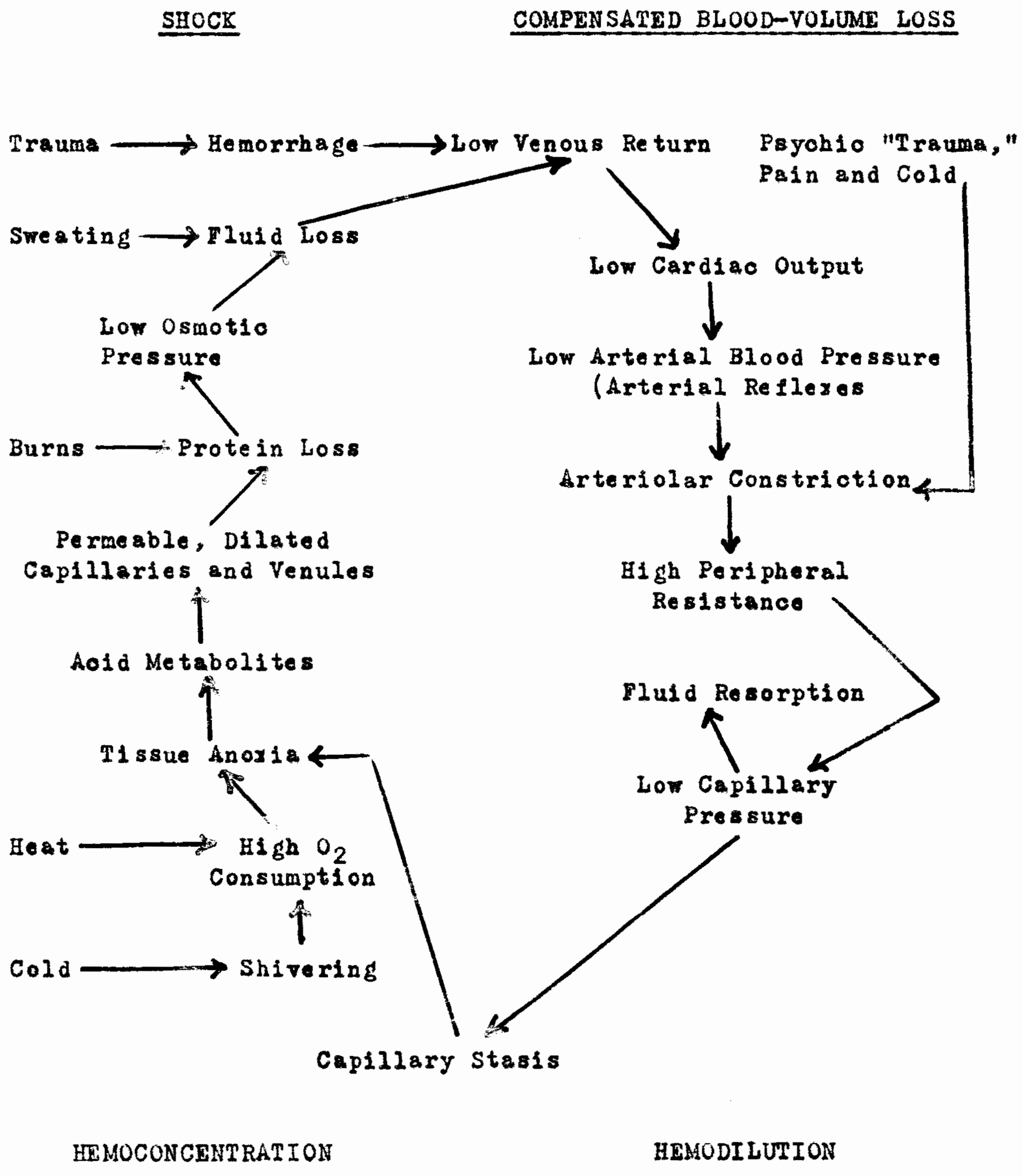

Figure I

Treatment of Shock:

Harkins (1945d) has found the shock accompanying burns to be so important that he considers it to be present in the early hours after a burn of great severity in spite of a satisfactory clinical appearance. If one waits for all the symptoms and signs of shock to develop, therapy is likely to be ineffective. According to Harkins (1945c), the hematocrit may rise to seventy during this period of time compared to a normal of forty-five. He states that the maximum hematocrit reading which is usually compatible with life is eighty.

Gordon (1945) stresses the necessity of making early, adequate, and repeated investigations of the circulating blood in patients with severe burns. He is of the opinion that it is impossible to make a diagnosis of hemoconcentration on one determination of the hemoglobin which shows a small increase because of the variations which appear in red blood cell counts and volume in hemoglobin among normal individuals. He does not place much emphasis upon a first hemoglobin reading of 110 per cent of the normal standards but accepts a hemoglobin of 115 per cent or over as indicative of hemoconcentration. If lower hemoglobin readings are found, but the patient's general condition and the appearance of the burned area indicate that hemoconcentration is likely to develop, frequent determinations of the hemoglobin should be done. By following this routine, this author has found that progressing hemoconcentration will be picked up.

Harkins (1945c) reports that in severe burns continued plasma leakage may cause hemoconcentration to continue for 36 to 48 hours and repeated testing of the hematocrit level every three hours or more may be necessary.

The burned patient needs constant vigilance during the shock phase. It has become generally accepted in the last ten years that the most important item in treating shock is to provide adequate fluid therapy. It is almost universally agreed upon by all authorities that the fluid of first choice is plasma. Cope (1944) sums up this attitude very thoroughly: "Theoretically the best solution to inject into the blood stream to replace the plasma is a solution chemically identical to that being lost."

According to Harkins (1945d), the use of fluid therapy should be directed toward the rapid replacement of acute deficits and the maintenance of daily needs. The rapid replacement of acute deficits is necessary to restore and maintain the normal blood volume, restore and maintain an adequate hemoglobin concentration of 13 to 16 grams per 100 cc., restore and maintain the plasma protein concentration above 6 grams per 100 cc., restore and maintain a satisfactory urinary output of at least 100 cc. per hour during the first forty-eight hours, and prevent dehydration and acidosis, and salt depletion.

<u>The Use of Plasma</u>:

According to Harkins (1945b) several liters of plasma may be lost from the burned surfaces and should be restored to the circulating blood. During the recent war, the use of plasma in treating war burns gained great prestige as a means of combating shock.

Gordon (1945) states that the plasma protein concentration usually remains fairly normal during the phase of acute hemoconcentration. Later, however, the plasma protein level falls due to continued loss of plasma, and edema persists or recurs. Since blood plasma is being lost it is logical to use blood plasma transfusions.

There have been devised several methods for determining the amount of plasma to be given. Some of the more commonly used rules will be presented:

I. Rule of Harkins (1945):

Give 100 cc. of plasma for every point the hematocrit is above the normal of 45. For children, the amount of plasma is calculated proportionately according to body weight, with the average adult weight set as seventy kilograms. If the plasma protein level is below normal, this method gives too low a value. In such a case, an additional 25% of the calculated amount of plasma should be added for every gram the protein level is below 6 grams per 100 cc.

II. Rule of Harkins (1945b):

Give 50 cc. of plasma for each percent of body surface burned.

III. Rule of Harkins (1945b):

Give 50 cc. of plasma for each 100,000 red blood cells exceeding the normal of five million.

IV. Rule of Harkins (1943):

Give 50 cc. of plasma for every point the hemoglobin is above the normal.

V. Rule of Wolff and Lee (1942):

The following formula can be used for calculating the protein deficit in grams:

$$3.5\ W = \frac{W\ (K-Hb_o)\ Hb_n\ P_o}{2\ (K-Hb_n)\ Hb_o}$$

"W" is the body weight in kilograms.

"K" is the grams of hemoglobin in 100 cc. packed cells.

"Hb_n" is grams of hemoglobin in 100 cc. normal blood.

"Hb_o" is grams of hemoglobin in 100 cc. blood after the burn.

"P_o" is the grams of protein in 100 cc. plasma.

The deficit or requirement in grams of protein may be converted into cubic centimeters of plasma by multiplication by the factor 14.

Wolff and Lee (1942) advise against the giving of plasma rapidly in a single large dose in an effort to compensate completely for the plasma protein loss. They have found that plasma continues to leak from the capillaries for the first forty hours, and if a large transfusion is given within that time, a goodly amount of the transfused plasma will leak out. To overcome this they use enough plasma during this period by continuous plasma infusion to keep the hematocrit down to within ten points of normal. After the period of plasma leakage is over, they determine the hematocrit and plasma protein and calculate the deficit. Then they give plasma, equivalent to eighty up to one-hundred percent of the calculated deficit of protein, slowly by continuous drip. They warn that too rapid intravenous therapy may lead to cardiac embarrassment or to pulmonary edema in a patient with a poor cardiac reserve. Cope (1943) is of the opinion that the restoration of normal blood concentration and volume by the administration of plasma itself probably tends to increase the edema of the burned tissues, even though it maintains a normal circulation for the unburned portions of the body.

Ackman, Gerrie, Pritchard, and Mills (1944) warn that the too liberal use of plasma when hemoconcentration does not exist may result in edema of the lungs, liver, and kidneys.

Wanamaker (1945) advises the making of repeated hematocrit readings in order to judge the success of the plasma therapy.

Harkins (1945b) believes that one liter of whole blood should be given for every two liters of plasma administered.

Berkow (1943) gives half of the calculated amount of plasma needed immediately and the rest he administers in divided doses in twenty-four hours.

The Use of Serum Albumen:

McLaughlin (1945) found, from his experiences in treating burn cases in the Navy, that the concentration of plasma in the standard Army-Navy package, which contained twenty-five grams of human serum albumen in 100 cc. diluent, to be very helpful in certain cases of major burns. The human serum albumen is not a complete substitute for blood plasma since it supplies only protein which is responsible for maintaining osmotic pressure and does not contain the prothrombin, complement, and antibody found in the globulin fraction. However, its extreme hypertonicity was very helpful in drawing out fluid from edematous tissues and thereby increasing the blood volume. He warns that it shouldn't be used in cases where there is dehydration unless accompanied by other intravenous fluid. It should be given at a rate not exceeding five cubic centimeters per minute.

The Use of Sodium Lactate:

The oral use of sodium lactate in treating burn shock was advocated by Fox (1944). He used large amounts of the chilled isotonic one-sixth molar solution orally immediately and at fifteen minute intervals thereafter. He administered seven to ten liters (ten to fifteen percent of body weight) of the isotonic sodium lactate during the first twenty-four hours after the burn. The solution was given though a small Levine tube which was passed through the nose and connected with a drip apparatus, so that the sodium lactate was administered constantly. This method was tried on cases with severe extensive third-degree burns during the shock phase with such successful results that he urges further trial of this therapy. Copious urinary output was present six to twelve hours after this therapy was begun. Albuminuria did not occur and the non-protein-nitrogen values in the blood did not become elevated. This method offers a simple and cheap means of combating shock.

Harkins (1945c) believes that it is all right to use sodium lactate by mouth or intravenously to combat acidosis, but should be used in conjunction with plasma, and not as a substitute for it. If sodium lactate is to be used for overcoming acidosis, he recommends the giving of 125 cc. of one-sixth molar solution orally or intravenously for each volume percent the plasma carbon dioxide is less than fifty-five volumes percent in a sixty kilogram man.

The Use of Saline:

The using of physiological saline solution in combating burn shock has been discarded by most authorities since the development of plasma infusion. Prioleau (1937) states that saline solution has only a temporary effect on raising the blood volume because the solution soon passes out of the circulation into the tissues, or is excreted by the kidneys. Cope (1943) states that the saline solution increases the outflow of the plasma filtrate from the capillaries by raising the blood pressure. In fact, he found that it increases the edema in the burned area because it has no osmotic effect, but merely passes out of the circulation into the tissues, or is excreted by the kidneys.

Wanamaker (1945) believes that saline solution should be administered in addition to the calculated amount of plasma in order to complete the replenishment of the plasma volume and supply water for kidney function.

Penberthy and Weller (1943) think that it is logical to administer physiological saline early in the treatment of shock because there is a marked lowering of blood chlorides accompanying the fluid loss from the blood. However, they advise that this therapy should be limited to the first twenty-four to forty-eight hours after the burn, since saline solution causes a marked drop in the plasma proteins as well as dehydration.

Rosenthal (1943) studied the mortality rates of different systemic therapies employed in treating shock in uniformly burned mice. He found that the administration of sodium chloride orally or intraperitoneally caused a significant reduction in the mortality rate. The intravenous administration of sodium chloride was less effective. In addition, it was learned that isotonic sodium chloride solutions given orally were superior to hypertonic solutions of sodium chloride. He showed that it was the sodium ion which was effective in combating shock since sodium acetate, succinate, bicarbonate, and lactate were as efficient as sodium chloride when administered orally. The author postulated that a histamine-like substance is liberated in burned patients which may cause a sodium deficiency.

The Use of Acacia Solutions:

Prioleau (1937) states that acacia solutions may be very effective in overcoming shock. They remain in the circulation much longer than saline or glucose solutions because of their colloidal nature, but their administration is not without danger.

The Use of Glucose:

Penberthy and Weller (1943) advise using glucose solution in conjunction with saline solution in the period of shock because it combats dehydration. It also aids in the prevention of liver damage during the period of toxemia.

Harkins (1945c) says that crystalloid solutions like saline and glucose may be used in equal quantities or less with plasma, but not as a substitute for it.

The Use of Water:

Burned patients are thirsty because of the fluid loss and will drink large quantities of water. This is particularly true of children, and because of the difficulty of administering intravenous fluid therapy, they are often encouraged to drink large amounts of fluid, because of the idea that fluids of all kinds are indicated and can do no harm under these conditions of impending shock. Williams, Eghart, and Trusler (1939) have found this reasoning to be fallacious. They have found that when water is ingested in large quantities by mouth, the burn shock is complicated by a water-logging of blood and tissues by a metabolic disturbance resembling water intoxication. Such a disturbance, they warn, may even be fatal.

Harkins (1945d) believes that the spontaneous ingestion of fluids and food according to the desires of the patient is usually adequate in mild burns, but in more severe injuries, intravenous therapy should be resorted to. He says that in burns involving less than ten percent of the body surface there is not sufficient loss of extracellular fluid to warrant intensive fluid therapy, and that the oral ingestion of water will suffice.

The Use of Whole Blood:

In recent years there has been some controversy concerning the use of whole blood transfusions for combating shock in severely burned patients. Up to this time, it was considered illogical to give whole blood during the shock phase because it would serve only to increase the already present hemoconcentration of the circulating blood.

However, Evans and Bigger (1945) checked the total circulating red cell mass shortly after the burn was received. They discovered that when only plasma was given a serious secondary anemia quickly developed. They believe that the deficit in the red cell mass is due for the most part to the sludging or trapping of large masses of red blood cells in the capillaries in and around the burned area. They admit that some of the deficit in the red cell mass, especially in women and children, may have been due to a previous existing anemia. They began to give whole blood transfusions to their burn cases despite the height of some hematocrit readings. They gave the whole blood infusions in amounts of 500 to 1000 cc. every six hours for the first forty-eight hours, along with enough saline and other fluids to keep up a urinary output of 50 to 100 cc. per hour. It had not been uncommon for them to find low plasma protein levels on the fourth or fifth day in patients who had been treated with plasma alone, but in this series of cases treated with large amounts of whole blood, the plasma protein levels were maintained at more nearly the optimum level. From their experience they believe that it is safe to give whole blood early in severe burns. Out of thirty-two patients so treated they had no instance of thrombophlebitis or pulmonary embolus clinically recognizable.

Abbott, Matthew, Griffin, Hirshfeld, and Meyer (1945) found that the early administration of whole blood plus an electrolyte solution orally to burned patients was effective in combating shock, as well as being effective in alleviating the anemia which usually appears later during the period of convalescence.

Harkins (1945b) believes that it is all right to give whole blood when plasma is not available. He also recommends that one liter of whole blood should be given for every two liters of plasma administered.

<u>The Use of Adrenal Cortex Extract:</u>

In the past five years, interest has been aroused by the use of adrenal cortex during the shock phase for the purpose of reducing capillary permeability and thereby preventing fluid loss.

Rhodes, Wolff, and Lee (1941) administered cortical extract, "Eschatin," intravenously in a dosage of five to ten cubic centimeters every six hours to twenty-six adults who had third degree burns ranging from nine to sixty-five percent of the body surface. Their results showed that in this group so treated, less plasma was required to overcome the shock phase and yet the plasma volume was brought back to normal considerably earlier than in the group which had not received adrenal cortex. They noted the presence of a marked chloride retention and offer the warning that no sodium chloride should be given to patients so treated unless indicated by chemical analysis of the blood.

However, Rhodes, Wolff, Saltonstall, and Lee (1943) found from later experiences in treating patients with extensive superficial burns with adrenal extract, that plasma by transfusion was not retained any better than in the control patients who received no extract.

Ingle and Kuezengi (1945) experimenting with normal male rats which were burned by immersion in water for sixty seconds at temperatures of either 68 or 70 degrees centigrade, found that the survival time was no longer in those rats which had been given hog adrenal extracts, 11-desoxycorticosterone acetate, than in those which had been treated with control solutions.

Ferguson (1945) treated a few of his burn cases with adrenal cortical extract in doses of five to ten cubic centimeters intravenously every six hours for two to three days. He concluded from his results that adrenal cortical extract may be an accessory agent of some value, but should not be relied upon to prevent fluid loss in severe burns.

The Use of Liver Extract:

Hechter (1945) experimented with the oral administration of liver extract upon burn shock induced in mice. One group of mice were given by stomach tube one cubic centimeter of Lederle's 15 unit liver extract which had been extracted with ether to remove the phenol preservative. The control group was given one cubic centimeter of water. One-half hour later, the groups of mice were anesthetized with ether and scalded under identical conditions. The average survival time and the percentage mortality were ascertained. They found that the liver extract treatment by mouth decreased the mortality 32 percent, and increased the survival time to 98 percent. They concluded from this work that there was anti-burn shock activity in liver extract when administered orally.

The Use of Heat:

The question of whether to apply heat to a burned patient in shock is still open to debate.

Pack and Davis (1946) advocate the use of external heat if the patient's temperature is subnormal.

Urkov (1946) takes a different stand on this question. While actual chilling of the patient is to be avoided, he emphatically states that the application of external heat to a patient in shock is contraindicated because we are dealing with a problem of excessive capillary dilatation, and all efforts are directed toward controlling and reducing it rather than at increasing it by such means as heat.

Ferguson (1945) explains that the result of overheating a patient in burn shock produces sweating and an unnecessary fluid loss in an already depleted patient.

Harkins (1945c) advises that the patient's body heat should be conserved, but additional heat such as hot water bags, heat lamps and the like should not be used.

<u>The Use of Oxygen:</u>

The giving of oxygen during burn shock is recommended by Harkins (1945c). Cope (1942) after experience with the victims of the Coconut Grove fire, warns that lung damage from both heat and irritating gases may be an added complication from civilian fires. One should always be aware of the possibility because the meager initial signs in the lungs is easily overlooked, with the result that pulmonary edema develops and the patient dies suddenly. He points out that when the patient starts to have asthmatic breathing, suction of the upper respiratory tract should be done at once, and oxygen therapy initiated through a nasopharyngeal catheter or an oxygen mask should be started. Sometimes, even tracheotomy is necessary and may be life-saving.

Berkow (1943) states that the inhalation of smoke, superheated air, or noxious gases produce edema and exfoliation in the respiratory tract, and is one of the chief factors in the cause of early death from burns.

PREVENTION OF INFECTION

The role that infection plays in burns is a very real one, and if not guarded against may lead to very serious consequences.

Meleney and Whipple (1945) point out that the bacteria causing infection in burns may be those normally found in the hair follicles or sweat glands or those deposited upon the surface subsequent to the burn. They have shown that in a superficial burn which is caused by a low temperature applied for only a short time, all of the organisms may not be killed in the hair follicles; but in a deep burn caused by a higher temperature applied for a longer duration, all of the bacteria in the skin in the central areas are probably killed except those bacteria at the margin, where the burn becomes superficial, which remain viable and capable of growth.

Bodenham and Brisk (1943) state that from their observations the most commonly found bacteria are hemolytic streptococci and pathogenic staphylococci. These organisms don't invade the tissues for six hours, so may be considered as contaminants during this short time. They warn that if the burn is not thoroughly cleaned within the next forty-eight hours, these organisms will have begun to invade the surrounding tissue and give rise to signs of an acute infection. If no specific therapy is administered, the infection persists until the wound heals.

Since it is realized that burns are easily subjected to infection, it is considered a wise practice to prevent exposure of the burned area to further contamination by resorting to aseptic technique. Harkins (1945b), Wanamaker (1945), McLaughlin (1946), Cope (1943) and others stress that when the burn is first seen, it should be covered with sterile sheets or towels without other medication until the definitive dressing can be put on. When treating the burn itself, strict aseptic technique should be observed. All personnel should wear sterile gowns and gloves as well as masks and caps. All instruments and other equipment should be sterile also.

In badly burned patients, sepsis can be expected to develop, thereby justifying the systemic use of sulfonamides or penicillin. Most present day authorities believe that either penicillin or one of the sulfonamide preparations should be used in the treatment of thermal burns in conjunction with the local and systemic therapy. Ludwig (1946) recommends that 20,000 units of penicillin be given every three hours intramuscularly until all second degree burns are healed or until the entire sloughing area of third degree burns has been removed. Bornemeier and Parsons (1946) give 25,000 units of penicillin intramuscularly to those patients with third degree burns who show evidence of sepsis. This therapy is continued up to the time that skin grafting is started.

Wanamaker (1945) reported that in those patients who didn't tolerate sulfonamides orally, good results were obtained with the administration of 20,000 units of penicillin intramuscularly every three hours.

Harkins (1945b) administered a prophylactic dose of two grams of sodium sulfadiazine intravenously to each patient with a major burn about three hours after admission. Subsequently, during which time sepsis still presented a menace, this drug was given orally in dosages of six grams daily.

Meleney and Whipple (1945) found that sulfonamides employed systemically alone or locally alone, or combined have not materially reduced the incidence or the severity of local infections in burns, nor have they delayed the development of infections nor have they eliminated the pathogenic organisms from the wounds. However, they did minimize the spread of the local infection into the general circulation and in this way decreased the incidence of septicemia and death.

In addition to the use of penicillin and sulfonamides, some authorities advocate the use of tetanus anti-toxin as a prophylactic measure against tetanus. Bornemeier and Parsons (1946) gave their series of burn cases a stimulating dose of tetanus toxoid shortly after the injury. Ackman, Gerrie, Pritchard, and Mills give 3000 units of tetanus anti-toxin sometime during the first twenty-four hours after the burn. In the Navy, McLaughlin (1946) gave all burn patients a booster shot of tetanus toxoid or 3000 units of anti-tetanic serum, if they had not been previously immunized.

Further considerations in the prevention of infection are discussed in the chapter on local treatment.

TOXEMIA

The period of toxemia follows the shock period, occurring from forty-eight to one-hundred-twenty hours, and occasionally as late as the third week after the burn. It is characterized by jaundice, anuria, stupor, delirium, and circulatory collapse despite adequate fluid therapy. The tentative causes of burn toxemia as reviewed by Harkins (1945d) are:

1. Inadequate treatment of shock or delayed treatment during this period with the consequent ischemic damage to the kidneys, liver or other organs. For example, he sites the failure to maintain blood volume by plasma and/or whole blood administration as being the prominent factor.

2. The excessive administration of electrolyte solutions with the result that the plasma proteins are diluted so that there is less than five grams of protein per hundred cubic centimeters, with the consequent development of edema. He warns that this is particularly dangerous when there is associated renal and/or cardiac damage.

3. Infection of the burned areas may produce toxemia.

4. The possibility of the absorption of a toxic substance from burned tissues, the substance being a protein product. He states that if this occurs the effect will be minimized by the maintenance of an adequate blood supply to all the tissues of the body.

Robertson and Boyd (1923) investigated the question of whether there was present in burns a burn toxin. They found that an alcoholic extract of burned skin contained a toxic agent which caused death when injected into normal animals. This was not found to be present in normal skin. This burn toxin was also present in the blood or red cells, but not in the plasma of burned animals. They concluded that a toxin formed in the burned tissues was absorbed into the blood stream and transported by the red blood cells.

Van Duyn (1945) believes that there is a true toxemia in burns, distinct from trauma and hemoconcentration on the one hand, and sepsis, on the other. He is of the opinion that the toxemia of burns is due to the absorption of some non-specific toxic substance from the burned area. He has suggested that the presence of toxemia can be recognized and its severity estimated by studying the degree of degenerative changes in the white blood cells. He admits that this may be more difficult to do when the picture is a mixed degenerative-regenerative one since inhibition and stimulation are both acting simultaneously. But during the toxic phase of burns the prognosis may depend upon the degree of degeneracy of the white blood cell picture. If the picture is a mixed degenerative-regenerative one, the prognosis is worse than if a similar degree of degenerative change is present alone.

In spite of the enormous amount of work that has been done on the subject, the final answer as to whether there is a specific toxemia in burns is not yet settled.

Treatment of Toxemia:

Most authorities, including Van Duyn (1945), Harkins (1945b), Urkov (1946), and others agree that the best treatment for the patient during the phase of toxemia is whole blood transfusions. Van Duyn (1945) believes that large whole blood transfusions should be begun immediately after the period of hemoconcentration is corrected and should be repeated if necessary as indicated by the appearance and disappearance of degenerative changes in the white blood cells. He has found this measure to be the best method of combating the toxemia of burns.

Ackman, Gerrie, Pritchard, and Mills (1944) stress the importance of keeping up the fluid intake to a minimum of 3000 cc. orally per day. They warn that sulfonamides orally or intravenously are not desirable especially if the urine volume is below 1000 cc. per day.

Harkins (1945b) and others agree that toxemia can be prevented and controlled by adequate fluid intake plus continuation of electrolyte therapy. He gives two liters of Hartmann's-lactate mixture (Hartmann's solution with one part of one-sixth molar sodium lactate) a day for a period of one or two weeks following a serious burn.

Van Duyn (1945) suggests the giving of crude liver extract in conjunction with the giving of blood transfusions during the toxemia phase because it has a beneficial effect on the degenerative white blood cell picture. He recommends a dose of 10 cc. intramuscularly every twenty-four hours during the toxemia phase.

NUTRITION

The question of nutrition assumes the most attention from the second week after the burn to the time when the last granulating surface is healed. Harkins (1945d) calls this the period of anemia, hypoproteinemia, avitaminosis, and sepsis. It is essential to realize the importance of nutrition in treating a burned patient because the future course of the patient's convalescence depends upon it. Because of the great loss of plasma protein during the early phase of the burn, hypoproteinemia and anemia are prone to develop. Levenson, Davidson, Lund, and Taylor (1945) warn than a continuous fall in the plasma proteins after the first week is a sign of marked tissue protein deprivation and than unless remedial steps are taken early, weight loss continues and the plasma proteins fall progressively. Edema and evidence of marked loss of weight and strength develop, and death from malnutrition may ensue. These authors observed in their patients with severe burns that the nutritional disturbances and the increased demand for protein were directly related to the extent of the burn. They advise that it is preferable to anticipate the requirements of the patient and to meet them before severe malnutrition occurs. They noted that the previous state of nutrition of the patient upon admission was an important factor in his subsequent course. The poorly nourished individual with diminished reserves was not equipped to withstand a prolonged period of negative nitrogen balance as well as the previously well-nourished individuals. In those patients whose nutritional requirements were not met, malnutrition developed, skin grafting and healing were delayed, and frequently death ensued.

Harkins (1945d) stresses that the burned patient should be kept in nitrogen equilibrium throughout the illness.

Harkins (1945c) suggests that blood transfusions be given to control anemia. He advises the giving of Rh- blood since sensitivity may develop in Rh- cases treated with repeated transfusions. In addition, he gives large doses of all the vitamins to prevent avitaminosis, iron to control anemia, and adequate sulfur, by feeding eggs, to help promote epithelization.

Levenson, Davidson, Lund, and Taylor (1945) have found that in those cases where the ingestion of large amounts of food is difficult, supplemental feedings by gavage or infusion is helpful. They recommend the giving of casein hydrolysates and mixtures of amino acids as sources of protein provided the essential amino acids are included. In addition to increasing the protein intake, the caloric intake must be maintained at a high level in order to prevent the breaking down of protein to supply the necessary body energy. They warn against the giving of excessive amounts of fat in the diet because of the possibility of liver disease. Most of the calories that are required must come from carbohydrates.

LOCAL TREATMENT

General Consideration:

The greatest amount of work in burn therapy has been done on the phase dealing with the treatment of the burned area itself. Almost every physician who has treated a burn has devised some new method which he has offered to the medical profession as the "best" means for treating burns locally. It is around these numerous therapies that so much controversy has arisen. No final conclusion can be drawn on any one method because each has its own supporters and opponents. So in discussing the individual local treatments, the advantages and disadvantages of each will be mentioned whenever possible. By doing this, the reader will be able to weigh the evidence and choose for himself that particular therapy which merits his approval.

In a study of the local treatment of thermal burns, it is wise to have a conception or a standard of what local therapy should accomplish. In regard to this, Koch (1942) says, "The four simple guiding principles in the treatment of raw surfaces are: not to add infection, not to add injury, to convert the open wound into a clean wound, and to close the wound at the earliest possible moment that closure can be safely accomplished."

As has been stated previously in the chapter on the prevention of infection, airborne bacteria must be kept out of the burn area by covering it with sterile drapes. Also it was stressed that when treating the burn surface, strict aseptic technique must be observed.

The status of debridement and cleansing of the wound before local medication is applied still remains controversial with the authorities about equally divided. Wanamaker (1945) believes that it is logical to convert a contaminated wound into a clean one by simple cleansing with white soap and water, followed by irrigation with warm saline solution. He also advises the removal of loose pieces of destroyed tissue which cannot be washed away, but leaving blisters untouched. Reese (1945) believes in the thorough washing of the burn, and the removing of all large blisters. McLaughlin (1946) recommends gentle irrigation of the burn with sterile saline solution, but does not advise scrubbing it with soap and water unless the area is grossly contaminated with foreign matter. He does not open the blisters, but does clip away all loose tags of skin. Levenson and Lund (1943) remove only large pieces of loose hanging skin. Cope (1943) states that no debridement or cleansing of any surface area was done on the victims of the Coconut Grove fire. He believes that the opening of blebs only leads to further plasma loss and infection. He feels that it is foolish to scrub the wounds because they can't be cleaned completely anyway and it only results in more extensive trauma to the tissues.

In regard to the changing of dressings, the tendency at the present time is to leave the initial dressing intact for a period of ten to fourteen days unless infection supervenes. Urkov (1946), in expressing the reason for this attitude says, "Frequent re-dressing introduces infection, causes pain, checks normal proliferation of new epidermis or of granulation tissue, and destroys such new tissues as attempt to form despite the excessive handling."

Collings (1945) has proposed six requirements that should be met by a preparation compounded for local use on burns. The preparation should:

"1. Relieve pain and present a comfortable dressing for the wound.

"2. Be suitable in ease of application and removal to the abilities of the person who is to use it.

"3. Not produce further tissue damage.

"4. Reduce or preferably prevent entirely the increased fluid passage from the capillaries.

"5. Produce stimulation of tissue repair.

"6. Prevent infection."

The popular local remedies used for treating thermal burns have been classified by Harkins (1943) under three main groups; namely, tanning agents, washing methods, and ointments. In this thesis, the various local therapies will be discussed under this form of grouping, with the addition of other methods, like pressure dressings, which cannot be satisfactorily grouped under any one of Harkins' three main groups.

<u>Tanning Agents</u>

Tannic Acid:

The first great step of progress in the treatment of thermal burns was initiated by Davidson (1925) who proposed to the medical world the use of tannic acid applied locally to the burned surfaces. His method was to cover the burned area with dry sterile gauze pads held in place by sterile gauze bandages. These dressings were then soaked with a 2.5% aqueous solution of tannic acid. After the part was found to have assumed a light brown color, all of the dressings were removed and the wound was thereafter left exposed to the air. It was carefully protected from mechanical injury, chilling, and bacterial invasion by a suitable cradle draped with sterile linen.

In a few of his cases he used a 5% tannic acid ointment (composed of equal parts of vaseline and lanolin as a base) in place of the aqueous solution. He found it to have a definitely beneficial effect, but was far less efficacious than the 2.5% aqueous solution. The chief value of the ointment was its use about the eyes where the astringent solution could not be used with entire safety.

Davidson listed the advantages of the tannic acid method over all other methods known at this time as follows: 1. The degree of toxemia was markedly less, 2. Gave quick relief of pain, 3. Reduced the incidence of infection, 4. Prevented local fluid loss, 5. Gave marked diminution in the amount of scarring, and 6. Resulted in a low mortality.

Conklin (1945) states that the consensus of opinion in the Army and Navy is that tannic acid does not give as good results as other newer means, but that it did establish the principle of prevention of plasma leakage which is accepted in the modern concept of burn therapy. He relates that during the early months of combat for Guadalcanal and the Solomon Islands, tannic acid was used frequently with the result that most of the third degree burns became infected within a week under the boardlike tan and required much patience and at times extensive surgery to obtain a clean granulating surface upon which to graft. He feels that it is all right to use tannic acid on second degree burns where less than one-fourth of the body surface is burned.

McClure, Lam, and Romence (1944) and Conklin (1945) report that tannic acid for tanning burned patients was toxic to the liver, even producing liver necrosis. Non-fatal cases frequently showed marked disturbance of liver function in the acute stage of the burn. In addition, tannic acid delayed wound healing and often converted border-line second degree burns into third degree burns.

Hirshfeld, Pilling, and Maun (1943) compared the reaction of normal tissues to tannic acid and other medications by applying them to donor sites of individuals who were receiving skin grafts. Their results showed that the tannic acid produced extensive tissue damage to the dermis while the eschar was being formed.

Berkow (1943) believes that rapid tanning still offers the best means for diminishing the local fluid loss. If plasma supplies are not available for immediate use, then tannic acid therapy is indicated.

Tannic Acid-Silver Nitrate:

Bettman (1935) introduced this modification of the tannic acid method. After removal of dead skin, he applied a five percent solution of tannic acid to the burned area, with cotton swabs. Over this was added a ten percent solution of silver nitrate. His experience with this form of treatment has been more satisfactory than with tannic acid alone. All the oozing and leaky areas were immediately sealed and the patient was encased in an impervious antiseptic dressing that formed in a matter of seconds instead of hours. Little or no shock or toxemia developed in his cases so treated. The coagulum was found to be thin and flexible, and the nursing problem was simplified. In addition, he noticed a definite decrease in the length of hospitalization compared to those cases treated with tannic acid alone.

Gentian Violet:

Aldrich (1933) introduced the use of gentian violet in the local treatment of burns. His method was to clean the wound up, open and remove all the bullae under aseptic technique, and then to spray the area every two hours for twenty-four hours with a one percent aqueous solution of gentian violet. Following this the spray is applied every four to six hours as he deemed advisable. It gave a more pliable eschar than tannic acid did and in addition had a rapid antiseptic action. He believed that this solution was specific against the beta hemolytic and gamma streptococci which are the chief invaders of burns. The greatest disadvantage of this method is that the dye stains the linen and everything else that comes into contact with it.

Triple Dyes:

Trabue (1943) treated his burn cases with triple dyes with satisfactory results. He used a solution of the following constituents:

Gentian violet	1:400
Brilliant green	1:400
Neutral acriflavine	1:1000

These solutions were mixed in equal proportions in distilled water and applied to the previously cleaned wound with an atomizer or spray, camel's-hair brush, or gauze mop. When dry, a light flexible tan or coagulum was formed, which in first-and second degree burns remained until the underlying area was healed. In the third-degree burns the tan usually separated at the end of ten days or two weeks leaving a clean granulating surface underneath. When the eschar began to separate, a dressing kept constantly moist with sterile saline was applied for a day or two to soften the slough and prevent pain. He found that this method of therapy was very effective in preventing the growth of Gram positive organisms in the burn.

Aldrich (1937) treated burned areas by spraying them with brilliant green and acriviolet. He states that this therapy gave a high specific action against both Gram positive and Gram negative organisms. He sprayed the burned areas every hour and states that the eschar developed in about eight hours. Unlike the tannic acid eschar, this one did not hide infection but softened and became moist if there was any underlying pus. Another favorable point was that the patients who were treated by this method did not require nearly the amount of skin grafting that was formerly done.

Brilliant Green:

Narat (1937) remarks that the advantages of using brilliant green are that frequent spraying is not required, pus is not allowed to accumulate under the eschar, and the germinal layer of the skin is not destroyed. His technique was to first clean up the burn and then paint the surrounding skin with a one percent solution of brilliant green in sixty percent alcohol. The burn area itself was painted with a one percent aqueous solution of brilliant green and then covered with a thin layer of gauze. In three to five days the alcoholic solution was applied to the burned area itself once or twice a day. In six to eight days, the burn was covered with one percent brilliant green in soluble jelly base gum tragacanth and covered with gauze. If any secretion was noted, the dressing was changed in two to five days.

According to Lavender (1939), the use of coagulants or tanning agents is contraindicated because the crust-covered areas become infected too often in spite of thorough debridement and strict asepsis. The eschar over a third degree burn seals over necrotic tissue which is an ideal culture media for bacteria to grow in.

Washing Methods

Saline Baths:

Wakeley (1941) has commented upon the fact that during the recent war, medical officers of the British Royal Navy were repeatedly impressed by the number of severely burned sailors who had spent several hours in the sea after their ships had been sunk and yet manifested remarkable freedome from shock and pain.

The use of saline baths for extensive and severe burns has gained particular favor in Great Britain. Goldberg (1944) used a modified method of open irrigation of the burn with sodium hypochlorite. With this method the patient is placed in a special type of bed made of waterproof silk cloth. The solution of sodium hypochlorite is allowed to flow constantly into the "tank" of silk. He has found that this type of burn therapy relieves pain and shock almost immediately. In addition, the course of healing can be observed readily.

Envelope Method:

The envelope method is a modified form of treating burns with saline baths. It was first introduced in England by Bunyan (1940) and consists of the use of envelopes or sacks made of silk cloth designed to fit over any part of the body. The envelope has an inlet and an outlet to allow the solution to flow through. The appropriately designed silk-coated envelope is applied to the burned limb or part that is to be irrigated and the open part is sealed to the body by a combination of specially prepared adhesives. This envelope is the only dressing used. A solution of normal saline to which has been added electrolytic hypochlorite in sufficient quantity to make a five percent solution (one ounce of hypochlorite to twenty ounces of saline) is run into the envelope and allowed to stay in for a period of twenty minutes. The envelope is gently agitated so as to give a swishing motion to the fluid. The irrigation is done three times a day during the infected stage of the burn and twice a day when the infection has ceased. Between the irrigations the wound is left undisturbed. However, he has found it to be better to have a continuous flow of the solution. The envelope remains on the patient until the burned area is epithelialized or is ready for grafting. Its advantages are that it is easy to use, it stops pain, and it acts to disinfect and prevent toxemia by removing all surface contamination and all the exudates. He has found that the use of normal saline solution alone at 100° F. was too strong a solution to use.

In burn cases in which a large part of the body is burned, thereby requiring almost complete irrigation of the whole body, he uses a portable collapsible bath into which the same solution is allowed to circulate.

Saline Dressings:

Ludwig (1946) treated 358 severe burns with saline solution, glycerin, and acetic acid in combination. He used fifteen percent glycerin and one-half percent acetic acid in normal saline. The method used was to apply a sterile three-inch gauze bandage with the finest mesh available. This was moistened with the solution. Over this was added five or six layers of heavy gauze which were also moistened with the solution until dripping wet. Then ace bandages were applied for pressure. The ace bandages were removed every eight hours at which time the heavy gauze bandages underneath were resoaked with the saline-glycerin-acetic acid solution, and then the ace bandages were reapplied. This routine was done for nine or ten days, at the end of which time the whole dressing was changed for the first time. Following the first dressing change on the ninth or tenth day, it was necessary to change the dressing in some cases every three days in order to remove additional sloughing tissues. The entire slough of an extensive third degree burn was removed easily by the eighteenth day. His results may be summarized as follows:

1. The odor from the burns was eliminated.
2. There was no maceration of the tissues by this method.
3. The glycerin in the solution tended to make the dressing changes easier and stimulated epithelization.
4. The acetic acid provided an adequate impediment to the development of pyogenic infection.
5. This type of dressings cleaned the burns rapidly, with the result that clean granulating surfaces were present for early skin grafting.
6. The very minimum of grafting was found necessary.

Mourot (1944) also found that wet dressings of two percent acetic acid were the best agent to clear up pyogenic infections in burns.

McLaughlin (1946) believes that continuous saline packs are the best treatment for burns of the genitalia and perineum.

Ointments

Vaseline:

The use of solid petrolatum, more commonly known as vaseline, has gained wide-spread popularity in recent years as a local application to thermal burns. Its chief use has been in conjunction with pressure dressings. Levenson and Lund (1943), McLaughlin (1946), Stockton (1944), Wanamaker (1945), Conklin (1945) and others have found vaseline or a modified vaseline ointment to be satisfactory as a local application to the burned area.

After superficial debridement of the burn, Wanamaker (1945) covers the area with an impregnated vaseline gauze dressing which contains:

	Gm. or cc.
Urea	10.0
Oxyguinoline	4.8
Chloratone	19.2
Liquid petrolatum	128.0
Olive oil	50.0
Wool fat	400.0
Petrolatum	500.0

The entire area is then covered with sterile gauze and compression dressings are applied.

McLaughlin (1946) states that in the Navy, he used petrolatum impregnated gauze bandage mesh in one, two, and three inch sizes and eight inch gauze rolls. These were prepared by immersing the bandages in boiling petrolatum for twenty minutes in order to insure the thorough impregnation of the entire roll. These gauze rolls were kept stored in sterile jars so that they would be readily available. The advantage of these rolls was that extensive burns could be covered more quickly than if individual gauze strips were used. Fingers and toes were wrapped individually with the one-inch rolls. The eight inch rolls were handy to use for large burns of the trunk.

Clowes, Lund, and Levenson (1943) studied one-hundred cases of burns from the point of view of comparing results of ointment gauze dressings with tanning agents. They found that areas treated with vaselined gauze became free of slough and were grafted earlier than areas treated with tannic acid, tannic acid-silver nitrate, and triple dye. Skin healing of second degree burns of the back took place a few days earlier if vaselined gauze ointment were used for treatment than if the tanning agents were used.

Conklin (1945) states that it is the common practice in the Army and Navy to merely cover the burned area with sterile vaseline-soaked fine mesh gauze strips, over which is placed a single layer of sterile gauze and then applying pressure dressings over the entire burn. From his experience, more rapid healing was noted when vaseline strips were used.

Aldrich (1943) believes that bland ointments like vaseline and boric acid are not of sufficient strength to combat local infection. He advises that if these are used, chemotherapy must also be resorted to.

Boric Acid:

In treating the victims of the Coconut Grove fire, Cope (1943) reports that boric-ointment gauze was applied directly to the burned area, without any previous debridement or cleansing of the surface. Dry sterile gauze was applied over this and then pressure dressings were put over all. Later, in preparation for skin grafting, boric acid solution-dressings were employed to aid in the liquification of the dry slough of the deep burns.

Harkins (1945b) warns that boric acid ointment may caúse toxicity in extensive burns.

Paraffin:

Pendleton (1943) is a strong advocator of the paraffin wax treatment for burns. He uses the following formula:

Petrolatum ----------------------	250 grams.
Liquid petrolatum (heavy) -------	150 cc.
Cod liver oil -------------------	50 cc.
Sulfanilamide powder ------------	50 grams.
Menthol -------------------------	1 gram.
Camphor -------------------------	1 gram.
Oil of eucalyptus ---------------	1 cc.

The camphor relives any itching or burning sensations. The oil of eucalyptus is used as a deodorant. The wax is sprayed on. The author has noted that pain is relived immediately and shock is minimized. Soot, oil, dirt, and dead skin all become incorporated in the wax which all comes off during the next few days, thus offering a gentle, delayed, non-traumatizing cleansing.

Zeiss (1940) has also sprayed burns with paraffin with satisfactory results. He stresses the importance of shaving and cleaning the skin around the burned area with soap and sterile water and drying it with ether. His method of application was to spray a thin layer of melted paraffin over the burned area. This layer of paraffin is gradually built up. A thin layer of sterile cotton is then spread over the wax over which more paraffin is painted on. The dressing is then completed by covering the paraffin with a thick layer of absorbent cotton which is either strapped or bandaged in place. The burns are dressed daily. The dressings, according to the author, strip off smoothly, easily, and painlessly. The advantages which he has noted from the paraffin-wax method of treating burns may be listed as follows:

1. Pain is relived at once.
2. The period of toxemia is lessened.
3. The slough separates early.
4. Infection is minimized.
5. Healing is rapid.
6. The patient is made ambulatory early.

Of special notice was the fact that in tar burns the tar combined with the paraffin wax and in twenty-four hours was stripped off leaving a clean burn surface.

<u>Chlorophyll</u>:

Finkel and Levine (1945) treated sixty-two cases of burns of varying degrees with a preparation of 1% chlorophyll, containing 10% benzocaine and 33.2% urea in an ointment base. For comparative purposes, wherever the lesions were multiple, they used at the same time ointments containing the same amount of urea and benzocaine without the chlorophyll, as well as preparations of cod liver oil and dye ointments. Their results showed that the healing time of the burns treated with the chlorophyll-urea ointment was reduced at least fifty percent; new epithelial tissue developed and matured almost overnight, with formation of skin that was flexible and smooth; no single case developed secondary infection where the wound was clean at the onset of treatment; several cases of long standing seen with infection at the beginning of treatment healed quickly with no or minimum scar tissue formation.

Collings (1945) used a bismuth ointment of the following formula:

Bismuth subnitrate ----------	33.5 grams.
Paraffin --------------------	44.5 grams.
Yellow petrolatum -----------	559.5 grams.

To a weighed amount of this ointment was added one percent of chlorophyll by weight. This maxture was autoclaved, allowed to cool, and then stored for long periods of time. Adrenal cortical extract was then added to the extent of two and one-half percent by weight and the mixture was stirred with a sterile spatula until homogenized. They found that the wound healing and epithelial proliferation were definitely accelerated by the local application of chlorophyll. They believe that this is due to the bacteriostatic effect of the chlorophyll. The adrenal cortical extract when applied locally reduced the local edema and fluid loss from the burned surface, aided drying, and promoted healing.

Cod-liver Oil:

The first extensive use of cod-liver oil in the treatment of thermal burns was done by Lohr (1934) who applied it to nearly one thousand cases of second and third degree burns. He used it as a salve or in combination with cod-liver oil plaster of Paris cast. He found that the closed method of treatment with the cod-liver oil plaster of Paris cast was particularly applicable in second degree burns of the extremities. These casts were kept on as a rule for two weeks. His results with this form of treatment were so good that skin grafting was unnecessary. In addition, the cod-liver oil controlled secondary infection of large areas and stimulated epithelization. He believed that these favorable effects were due to the vitamins A and D present in the cod-liver oil.

Berlein and Davis (1939) treated burns with a modified cod-liver oil mixture of the following substances:

60% Cod-liver oil.

40% Crude vaseline.

This preparation was smeared onto the burn, and gauze bandages were placed over this. The dressings were changed daily for several days until the initial reaction had subsided somewhat and then they were changed every three or four days. The initial cleansing of the burn area consisted of opening the blebs, peeling away the dead skin, and removing the transudate. With this method of therapy, they saw no infections. Pain was relieved at once. In addition, it seemed to prevent the formation of contractures and scars.

Sulfa Drugs:

With the introduction of the sulfonamides as chemotherapeutic agents, the use of topical ointments containing sulfa drugs became popular in the local therapy of burns.

After washing the burned area with very mild soap and debridement of necrotic tissue, Marshall and Greenfield (1944) applied an ointment containing:

2% allantoin.

5% sulfanilamide.

5% sulfathiazole.

Out of twelve patients treated with this preparation, eleven of them showed no signs of keloid formation, and healing was complete without the necessity of skin grafting. They think that the allantoin has a chemical debriding effect on necrotic cells and also stimulates healing by increasing cell proliferation.

Jenkins (1945) tried a sulfathiazole emulsion ointment of the following constituents:

Oil Phase:

Petrolatum --------------- 48 cc.

Arlacel ------------------ 2 cc.

Aqueous Phase:

Sulfathiazole ------------ 5 grams.

Tween 80 ----------------- $\frac{1}{4}$ cc.

Water q.s.a.d. ----------- 100 cc.

He found this treatment to be very satisfactory for burns and suggests that it would be especially suited for the first aid type of burn treatment when cleansing procedures are not feasible. He observed that sufficient sulfathiazole was liberated from the ointment to have at least some bacteriostatic effect which was not obtained by grease dressings alone. The liberation of sulfathiazole is controlled in this ointment preparation to the extent that overwhelming systemic absorption of the sulfathiazole does not occur, yet the sulfathiazole continues to be liberated for a period of a week or more and thus permits a continuous bacteriostatic effect.

Reese (1945) treated forty-three cases of burns of various degrees with transparent sulfonamide-containing films and pressure dressings. The films were made of methyl-cellulose and plasticizer and were 0.004 inches thick. These films contained 20% sulfonamide and 10% sulfacetimide. He estimated that one square centimeter of the film contained three milligrams of the sulfonamides. The method used consisted of first, cleansing and debriding the burned area, and then, covering the area with the film. Pressure dressings were then applied over the film. The superficial dressings (not the film) were removed on the fourth or fifth day for inspection of the burn through the transparent film to determine the extent of healing.

He observed that the healing time compared favorably with most of the common methods of local therapy. The chief advantage of the film is that it forms a protective transparent coating which remains on the burned area until full healing has occurred. Thus, painful redressings are eliminated and injury to partially devitalized structures and fragile newly-growing epithelium is prevented. However, he believed that the good results obtained were due to his use of strict aseptic precautions and application of pressure dressings rather than to the sulfonamides in the film!

Stockton (1944) recommends the use of sulfathiazole powder applied with a powder puff over the use of a sulfathiazole ointment because of the higher concentration of the powder on the burned area.

Conklin (1945) states that the topical application of ointments with sulfonamides is of questionable value. Harkins (1945b) warns that there may be too much absorption of sulfonamides if a water-based sulfonamide ointment is used. Welbron (1943) has found that sulfanilamide applied to a burned area may be rapidly absorbed and result in high blood sulfanilamide levels associated with alarming clinical symptoms. He says that these symptoms may be exaggerated by the dehydration that is found in the early phase of burns. He suggests that the amount of sulfanilamide that is to be applied locally to burned areas be kept within therapeutic dosages, and that the blood sulfanilamide level be carefully watched.

Other Methods

Fibrin:

Macfarlane (1943) dressed burns with human fibrin and found such a slight clinical advantage over other methods that he felt that it hardly made the trouble involved in preparation and application worthwhile. However, the membranes did relieve pain rapidly and formed confortable dressings. In those cases that became infected, the membranes were lysed. Healing did not appear to be much more rapid than in other methods.

Hawn, Bering, Bailey, and Armstrong (1944) used human fibrinogen and thrombin mixtures applied locally and found that there was no deleterious effect upon the rate of healing. The chief advantage of this method was that pressure dressings were not required.

Plasma Sheets:

Pollock (1944) applied plasma sheets to the burned area after debridement. These sheets were prepared by adding 20 cc. of sterile water, 1.5 to 2 grams of dried plasma, and 0.2 grams of sulfanilamide powder to a Petri dish. This preparation was then dried in an oven at 140° centigrade until a firm sheet was formed. This is then applied directly to the burn. The application of this method to burns was found to stop plasma loss immediately. The plasma sheet required no dressing. It would adhere to second and third degree burns, but not to unbroken skin. One objection to its use was that there was some temporary stinging or burning sensation when it was first applied.

Miscall and Joyner (1944) treated burns locally with hemostatic globulin and plasma clot dressings. The mixture was prepared by placing strips of sterile fine mesh gauze bandage (4 by 8 inches) in a sterile basin. Blood plasma is then rapidly mixed with commercially prepared "hemostatic globulin" which has thrombic activity, and this mixture was then poured over the gauze in the basin. This forms a gel-impregnated gauze which was accurately layered over the debrided burned area. Over the plasma clot dressing was then placed a dressing of sterile gauze reinforced with elastic bandage in order to provide pressure. The absorption of serum by the heavy gauze permitted the dressing to dry in six to twelve hours. They found that 10 cc. of 10% hemostatic globulin would clot 100 cc. of plasma firmly in three to ten minutes. Pain was found to be uniformly absent. Surface and tissue plasma loss were prevented, and rapid and healthy epithelization ensued.

Horse Serum:

Rabinowitz and Pelner (1944) treated burns locally by spraying them with normal horse serum every hour at first and then at longer intervals. The serum and plasma were coagulated by playing a small heat lamp over the area. After a period of ten days to two weeks, the burned area was soaked in sterile saline, and as the eschar began to separate, spraying and saline washings were repeated until complete epithelization took place. They treated fifty-two patients with severe second and third degree burns by this method, and had gratifying results. The burned parts showed no signs of infection, were absent of pain, had only a small amount of scarring, and epithelized rapidly. No skin grafting was required. They theorized that since epithelization takes place along a fibrin network, it does not take place readily in large burns unless aided. The artificially coagulated serum and the wound plasma acted similarly to a fibrin network and thus aided epithelization.

Pressure Dressings:

One of the most recent revolutionary methods as well as one of the most satisfactory methods for treating thermal burns locally has been the use of pressure dressings as proposed by Koch (1942). He believes that pressure dressings are the most satisfactory means for arresting local fluid loss and for relieving pain. He covered the burned area with sterile gauze saturated with petrolatum. Over this was placed several layers of sterile gauze to absorb oozing serum. Then sterilized mechanics' waste or sea sponges were applied and held firmly in place with an elastic bandage so that smooth and uniform compression was exerted over the injured area. This dressing was left on for ten to fourteen days unless infection developed under the dressing.

McLaughlin (1946) used petrolatum dressings covered with several layers of sterile gauze over which a thick layer of fluffed waste or cellulo-cotton was applied. He says that sheets of cellulo-cotton facilitated the application of the dressing for an extremity, while mechanics' waste was better for the areas about the axillae, neck, face, and groin. He held the mechanics' waste in position by applying a few turns of gauze over which ace bandages were applied firmly to maintain pressure. He suggests that a stockinette gives evenly distributed pressure as well as a better appearing dressing.

Wanamaker (1945) advises that in treating burned extremities with pressure dressings the greatest pressure should be at the most distal portion of the burned surface since a constricting band proximally would result in occlusion of blood flow, which in turn would cause edema. For the shoulders, thorax, and abdomen wide stockinet bandages cut on the bias should be used because they are elastic and can be made to fit snugly over these areas without slipping out of place.

Harkins (1945b) states that one of the biggest advantages of the pressure dressings, besides preventing local fluid loss, is that fewer burns have to be grafted.

Siler and Reid (1942) after having treated over one hundred patients with severe burns by the application of pressure dressings concluded that the pathologic-physiologic changes resulting from burns was less severe and more readily controllable under this form of therapy than by other methods previously employed. Not only was the incidence of infection slight, but the patients were more comfortable and more easily cared for.

The application of skin tight plaster casts works on the same principle as that of pressure dressings. Levenson and Lund (1943) have used plaster casts for the treatment of burns of the extremities. They place one layer of sterilized petrolatum gauze over the whole area to be covered with the plaster. This is carefully fitted between the fingers. This layer is covered with four layers of sterile gauze, carefully fitted so as to not have overlapping. Very thin plaster slabs are then molded over the extremity front and back. A thin layer of rolled plaster completes a nearly skin tight, light, well-fitting plaster which extends about four inches above the burn. The fingers are placed in a semiflexed position. The original cast is left on for fourteen days. If at the end of this time the burn is not healed, another cast is applied and left on for a further period of fourteen days.

Conclusion

In the final analysis, the greatest progress has been made in the systemic treatment because of the discoveries in the pathologic-physiology and pharmacology of burns, but this cannot be said to be true in the local treatment. The finding of no single local treatment which is completely satisfactory or applicable to all burned areas of the body or even for burns of the same degree is proof in itself that there is still required further investigation in burn therapy.

SUMMARY

1. The general considerations in the treatment of thermal burns have been discussed with emphasis upon the clinical phases of burns.
2. The systemic treatment of the burned patient has been reviewed with particular emphasis upon the treatment of pain, shock, and toxemia and the prevention of infection.
3. The importance of providing adequate nutrition for the burned patient has been stressed.
4. A number of the more commonly applied local treatments for thermal burns have been described with a discussion of each ones advantage and disadvantage.

SELECTIVE BIBLIOGRAPHY

Abbott, W. E., Matthew, A. P., Griffin, E. G., Hirshfeld, J. W., and Meyer, F. L. 1945 Metabolic alterations following thermal burns: the use of whole blood and an electrolyte solution in the treatment of burned patients. Ann. of Surg., 122:678-691.

Ackman, D., Gerrie, J. W., Pritchard, J. E., and Mills, E. S. 1944 Report of management of burns using occlusive compression dressing with sulfathiazole (sulfonamide) emulsion. Ann. Surg., 119:161-177.

Aldrich, R. H. 1933 The role of infection in burns: the theory and treatment with special reference to gentian violet. New Eng. Med. Jour., 208:299-309.

Aldrich, R. H. 1937 Treatment of burns with compounds of analine dyes (acriviolet and brilliant green). New Eng. J. Med., 217:911-914.

Barnes, J. P. 1933 Review of modern treatment of burns. Archives of Surgery, 27:527.

Berkow, S. G. 1924 A method of estimating extensiveness of lesions (burns and scalds) based on surface area proportions. Arch. Surg., 8:138-148.

Berkow, S. G. 1943 Program for emergency treatment of extensive burns. U. S. Nav. M. Bull., 41:946-952.

Berlein, I. C. and Davis, J. R. 1939 The treatment of burns with cod liver oil and vaseline. Ohio State Med. J., 35:267-269.

Bettman, A. G. 1935 The tannic acid-silver nitrate treatment of burns: a method of minimizing shock and toxemia and shortening convalescence. Northwest Med., 34:46-51.

Biddle, J. C. 1901 Burns and their history and treatment. Penn. Med. J., 5:583.

Bodenham, D. C. 1943 Penicillin; value for infected burns. Lancet, 2:725-728.

Bornemeier, W. C. and Parsons, L. 1946 The treatment of burns; report of 155 cases. Surg., Gyn., and Obst., 82:311-318.

Bunyan, J. 1940 Envelope method of treating burns. Proc. Roy. Soc. Med., 34:65-70.

SELECTIVE BIBLIOGRAPHY

Clowes, G. H. A., Lund, C. C., and Levenson, S. M. 1943 Surface treatment; comparison of results of tannic acid, silver nitrate, triple dye, and vaseline or boric ointment as surface treatments in 150 cases of burns. Ann. Surg., 118:761-779.

Collings, G. H. 1945 Chlorophyll and adrenal cortical extract in the local treatment of burns. Am. J. Surg., 70:58-63.

Conklin, F. L. 1945 Treatment of burns. Mil. Surg., 96:139-142.

Cope, O. 1943 Care of victims of Coconut Grove fire at Mass. Gen. Hospital. New Eng. J. Med., 229:138-147.

Cope, O. 1944 Chemical aspects of burns. J. A. M. A., 125:731.

Davidson, E. P. 1925 Tannic acid in the treatment of burns. Sug., Gyn., and Obst., 41:202-221.

Dingwall, J. A. 1943 Clinical test for differentiating second from third degree burns. Ann. Surg., 118:427-429.

Dingwall, J. A. and Andrus, W. DeW. 1944 Comparison of various types of local treatments (especially results with sulfonamide-impregnated plastic film) in controlled series of experimental burns in human volunteers. Tr. Am. S. A., 62:377-386.

Dupuytren (cited by Pack, 1934).

Evans, E. I. and Bigger, I. A. 1945 The rationale of whole blood therapy in severe burns; a clinical study. Ann. Surg., 122:693-705.

Ferguson, L. K. 1945 Treatment of burns. Bull. New York Acad. Med., 21:127-144.

Finkel, M. D. and Levine, A. J. 1945 Chlorophyll urea ointment in the treatment of burns and chronic ulcers. Indust. M., 14:730.

Fox, C. L. 1944 Oral sodium lactate in burn shock. J. A. M. A., 124:207-212.

Goldberg, H. M. 1944 Extensive burns treated in open irrigation chamber with sodium hypochlorite solution. Lancet, 1:371-372.

SELECTIVE BIBLIOGRAPHY

Goldblatt, D. 1927 Contribution to the study of burns, their classification and treatment. Ann. Surg., 85:490-501.

Gordon, R. A. 1945 Significance of blood changes in treatment of patient. Anesth. and Analg., 24:78-84.

Harkins, H. N. 1943a Physiologic aspects of the treatment of burns. Am. Acad. Orthop. Surgeons, Lect., 186-188.

Harkins, H. N. 1945b Treatment of burns. J. South Carolina M. A., 41:27-30.

Harkins, H. N. 1945c The general care of the patient with burns. Nebraska M. J., 30:175-176.

Harkins, H. N. 1945d Fluid and nutritional therapy in burns. J. A. M. A., 128:475-479.

Hawn, C. V., Bering, E. A., Bailey, O. T., and Armstrong, S. H. 1944 Fibrinogen and thrombin in surface treatment of burns. J. Clin. Investigation, 23:580-585.

Hechter, O. 1945 Liver principle which is effective against burn shock; further studies. Am. Heart J., 29:499-505.

Hirshfeld, J. W., Pilling, M. A., and Maun, M. E. 1943 Comparison of effects of tanning agents (especially tannic acid) and of vaseline gauze on fresh wounds of man (donor sites for skin grafts). Surg., Gynec. and Obst., 76:556-561.

Ingle, D. J. and Kuezengi, M. H. 1945 The survival of non-adrenalectomized rats in burn shook with and without adrenal cortical hormone treatment. Am. J. Physiol., 145:203-205.

Jenkins, H. P. 1945 Sulfathiazole (sulfonamide) ointment; further studies on preparation and use. Surg., Gynec., and Obst., 80:85-96.

Koch, S. L. 1942 The treatment of raw surfaces resulting from burns and wounds. Jour. Iowa State Med. Society, 32:445.

Lavender, H. J. 1939 Treatment and management of burn cases. Am. J. Surg., 45:534-538.

Lepage, G. 1945 Modern trends in burn therapy as seen by the British. Med. World, 63:533-538.

SELECTIVE BIBLIOGRAPHY

Levenson, S. M., Davidson, C. S., Lund, C. C., and Taylor, F. H. L. 1945 Nutrition of patients with thermal burns. Surg., Gynec., and Obst., 80:449-469.

Levenson, S. M. and Lund, C. C. 1943 The treatment of burns of the extremities. J. A. M. A., 123:272-277.

Lohr, W. 1934 Report of 1000 cases of burns. Chirurg, 6:263.

Ludwig, F. E. 1946 The use of saline solution, glycerin, and acetic acid in the care of burns: an odorless method of treating burns. Surgery, 19:486-491.

Lundy, J. S., Adams, R. C. and Seldon, T. H. 1944 Plasma and blood in treatment of shock. S. Clin. North America, 798-807.

Macfarlane, R. G. 1943 Human fibrin as dressing for burns. Brit. M. J., 2:541-543.

Maguire, D. L. 1945 The treatment of extensive second and third degree burns. J. S. Carolina M. A., 41:246:248.

Marshall, W. and Greenfield, E. 1944 Modified nonadherent gauze pressure treatment of burns. Am. J. Surg., 63:324-328.

McClure, R. D., Lam, C. R., and Romence, H. 1944 Tannic acid and the treatment of burns: an obsequy. Ann. Surg., 120:387-405.

McLaughlin, C. W. 1946 The treatment of major burns in naval warfare. Nebraska M. J., 31:11-19.

Meleney, F. L. and Whipple, A. O. 1945 Statistical analysis of study of prevention of infection, with special reference to sulfonamides. Surg., Gynec., and Obst., 80:263:296.

Miscall, L. and Joyner, A. 1944 Hemostatic globulin and plasma clot dressing in local treatment of burns. Surgery, 16:419-421.

Morani, A. D. 1945 Modern treatment of burns. Med. Woman J., 52:33-36.

Mourot, A. J. 1943 The treatment of burns. Virginia M. Monthly, 71:25-28.

SELECTIVE BIBLIOGRAPHY

Narat, J. K. 1937 Treatment of burns with brilliant green. Am. Jour. of Surg., 36:53-55.

Pack, G. T. 1946 Thermic injuries. The Cyclopedia of Medicine, Surgery, and Specialties. Philadelphia, F. A. Davis Company. 14:1030-1050.

Pack, G. T. and Davis, A. H. 1946 Burns. Philadelphia, J. B. Lippincott.

Penberthy, G. C. and Weller, C. N. 1943 Treatment of burns (including shock). Am. Acad. Orthop. Surgeons, Lect., 188-198.

Pendleton, R. C. 1943 Paraffin wax open air treatment of burns. J. A. M. A., 122:414-417.

Prioleau, W. H. 1937 Shock: present day conception and treatment. Industrial Med., 6:506-507.

Rabinowitz, H. M. and Pelner, L. 1944 Treatment of burns. Am. J. Surg., 64:55-63.

Reese, E. C. 1945 Local treatment with pressure dressings and films containing sulfonamide. Am. J. Surg., 67:524-529.

Rhodes, J. E., Wolff, W. A., and Lee, W. E. 1941 Use of adrenal cortical extract in treatment of traumatic shock of burns. Ann. Surg., 113:955.

Rhodes, J. E., Wolff, W. A., Saltonstall, H., and Lee, W. E. 1943 Adrenal cortical extract in burn shock; further experiences. Ann. Surg., 118:982-987.

Robertson, B. and Boyd, G. L. 1923 The toxemia of severe superficial burns. J. Lab. Clin. Med., 9:1-14.

Rosenthal, S. M. 1943 Experimental chrmotherapy of burns and shock: effects of systemic therapy on early mortality. Pub. Health Rep., 58:513-522.

Siler, V. E. and Reed, M. R. 1942 Clinical and experimental studies with the Koch method of treatment of heat burns. Ann. of Surg., 115:1106-1115.

Stockton, A. B. 1944 Local treatment of war burns. Stanford M. Bull., 2:71-73.

SELECTIVE BIBLIOGRAPHY

Trabue, C. C. 1943 Triple dyes. J. Tennessee M. A., 36:13-19.

Urkov, J. C. 1946 The critically burned patient. Am. J. Surg., 71:242-252.

Van Duyn, J. 1945 Degenerative white cell picture as indication of toxemia. Arch. Surg., 50:242-252.

Wakeley, C. P. G. 1941 War burns and their treatment. Practitioner, 146:27.

Wanamaker, F. H. 1945 Care of burn casualty. U. S. Nav. M. Bull., 44:1239-1244.

Welborn, M. B. 1943 Sulfanilamide (sulfonamide); absorption from burned surfaces. J. Indiana M. A., 36:447-448.

Williams, H. S., Eghart, H. L., and Trusler, H. M. 1939 Burn shock. J. A. M. A., 113:2207-2214.

Wolff, W. A. and Lee, W. E. 1942 A simple method for estimating plasma protein deficit after severe burns. Ann. of Surg., 115:1125.