THE PROBLEM OF BURN SHOCK COMPLICATED BY PULMONARY DAMAGE*

OLIVER COPE, M.D., AND FREDERIC W. RHINELANDER, M.D.

FROM THE DEPARTMENT OF SURGERY OF THE HARVARD MEDICAL SCHOOL AND THE SURGICAL SERVICES AT THE MASSACHUSETTS GENERAL HOSPITAL, BOSTON, MASS.

The treatment of shock of the casualties demands priority in a disaster. Proper immediate shock therapy may prevent early death among burn casualties and also influence the future course because the fight against infection depends upon the patient's well-being.

The pulmonary lesions in the casualties of the Cocoanut Grove disaster were unexpected and complicated the care of the shock. The usual plan of action for the care of shock due to burns had to be promptly modified. Carbon monoxide poisoning with its bright cherry-red color of the burn surfaces and mucous membranes, and the inflammation of the burned lungs and airways were quickly detected, but there was a delay in recognizing that the resulting anoxia was the cause of the mania in some of the patients. Dr. Beecher, in his article, deals with the problems of anoxia. In this article we detail the modifications deemed necessary for the care of the burn shock.

A disaster close to hospital facilities offers the ideal circumstances for the care of shock. For the prevention of shock is more effective than its treatment when once it is established. This is particularly true of burn casualties where the shock, except for the primary phase due to pain and exposure, has a longer latent period than shock from hemorrhage. The Cocoanut Grove night club was sufficiently close to the Massachusetts General Hospital so that all the casualties arrived within two hours of the onset of the fire. The shock that had been suffered by the time of arrival was due not to burns so much as to the anoxia, exposure and pain. The steps taken in the treatment of shock were as follows:

Control of Pain.—Each patient immediately upon admission was given an injection of morphine. This procedure, routine in the treatment of burns, is based on the concept that prolonged pain in itself leads to shock. That a few of the patients received an overdosage from a mistaken idea of therapy is emphasized by Dr. Beecher.

That pain may exert an additional and indirect influence on shock is illustrated by Case 12, a young naval officer. One of the earliest patients to arrive, he walked in. There was a delay before he received the morphine. The pain in his hands was so intense that he was unable to lie down but jumped up and down on the floor waving his hands. Twenty-five hours later he died of the pulmonary complication. It is a question whether this initial excessive physical exertion may not have increased the pulmonary edema. It is a common belief as a result of experiences in the last war that exertion precipitates the onset of pulmonary symptoms and edema following phosgene inhalation.

* The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Harvard University.

General anesthesia was deliberately omitted as part of the treatment of the casualties since it has a deleterious influence in patients in impending shock. The surface treatment, with no débridement and no cleansing, was planned with this in mind.

Minimum of Manipulation.—Every effort was made to reduce manipulation in the care of the patient. Rolling a patient over abruptly tends to disturb the vascular equilibrium with which he is responding to the diminishing blood volume. But one shift of the patient was made, from stretcher to bed. All subsequent procedures were carried out in bed. Had débridement and cleansing been performed it would have necessitated a transfer of patient from bed to operating table and back, as well as the manipulation incident to the débridement.

Plasma Therapy.—All except ten of the patients were given plasma intravenously. Of those receiving no plasma, five had minor pulmonary complications and no surface burns, and were discharged from the hospital in the first few days (Cases 9, 10, 21, 30, and 31); the other five had minor surface burns and various degrees of pulmonary signs (Cases 1, 3, 5, 15, and 24). Because of the inevitable delay in the thawing of plasma in the blood bank, the early arrivals did not receive plasma promptly, whereas the later arrivals had plasma running into their veins within five minutes of entry. Plasma therapy was deliberately withheld from the patients with *early* signs of pulmonary damage and no, or minor, external burns. To one patient, (Case 6) with no external burn but severe pulmonary damage, one unit of plasma was given later in the night.

The initial dosage of plasma was determined on the basis of the surface area of the burns.* For each 10 per cent of the body surface involved, it was planned to give 500 cc. in the first 24 hours. Because the plasma delivered by the Blood Bank during the first 36 hours was diluted with an equal volume of physiologic saline solution, the patient was to receive 1000 cc. of fluid for each 10 per cent burned.

The plasma dosage was modified subsequently on the basis of repeated hematocrit and serum protein determinations. The hematocrit readings on blood taken in the third hour after entry were available by 3 A.M. of the first morning. The rate of plasma administration was increased in the patients showing hemoconcentration. Four additional blood hematocrit and protein determinations were made in the first 24 hours. Three determinations were made in the second 24 hours; two in the third; and daily thereafter as indicated. No attempt was made to apply a formula to the hematocrit reading to determine the dosage of plasma needed, it was simply run in faster when hemoconcentration was present. The same basic formula of surface area

* No attempt was made to judge the amount of plasma which might be lost from the circulation into the damaged pulmonary tissue. That the lungs accounted for some of the plasma lost is indicated by the fact that those lungs examined postmortem by Drs. Mallory and Brickley weighed nearly one kilogram more than an average pair of normal lungs.

was adhered to.* Only two patients (Cases 4 and 39) showed a hematocrit reading below normal in the first 24 hours.

The results of this intravenous plasma saline therapy were apparently satisfactory in the initial 12 hours. Although forms of shock certainly existed, little or no burn shock was encountered.† No patient died in the first 12 hours. (The unknown number who died immediately at the entrance from suffocation are excluded.) The seven deaths counted occurred from 13 to 62 hours after admission and all were considered to have been caused by pulmonary damage and anoxia.

Little or no hemoconcentration, as judged by the hematocrit and serum protein, occurred in the patients with the most extensive surface burns. For example, in three of these patients (Cases 13, 20 and 34) the highest recorded hematocrits were 53, 55, and 54 per cent. The hematocrit of a severely burned female (Case 8) did reach 65 per cent, the highest recorded figure.

Unsuspected hemoconcentration appeared in patients with pulmonary damage and lesser external burns. The hematocrit of two of these (Cases 5 and 19) reached 55 and 59 per cent. This discrepancy was undoubtedly due, in part, to the fact that more attention was paid to prompt plasma administration to those who were severely burned. It is evidence, on the other hand, of the early loss of plasma into the damaged pulmonary bed.

All patients showing a severe degree of the typical burn pattern, burns of the head and hands, developed hemoconcentration and eventually required more plasma in the first 24-hour period than had been calculated by the surface area formula. Massive edema formed beneath the deep burns of the face and scalp in spite of the pressure dressings. The edema fluid was dispersed downward to the neck and over the shoulders and chest. Apparently, in the deeper burns there was a correspondingly deeper damage of the subcutaneous capillary bed with an increasing extravasation of plasma into the loose areolar tissues beneath face, scalp, and downward into the fascial planes of the neck. In the mild burns of the face, such massive edema did not occur and hemoconcentration was not excessive.

* When the hematocrit reading was 60 per cent or over, three units of plasma were given in the four hours before the next hematocrit reading. If the hematocrit was 55 to 59 per cent, two units were injected, if 50 to 54 per cent, one unit.

† Burn shock is defined as low blood pressure shock, with hemoconcentration and diminished blood volume due to loss of plasma fluid into the burn area. Blood pressures below 100 mm. Hg. were recorded on several of the patients in the first 12 hours. One man (Case 26) entered with a blood pressure of 80 mm. He had been sprayed with water and was chilled. His pressure recovered spontaneously within 30 minutes. The woman (Case 2) who had severe anoxia in the first seven hours, in part due to an overdose of morphine, and who received artificial respiration through an intratracheal tube, showed an irregular blood pressure curve with several systolic readings below 90, and one of 70. (She developed auricular fibrillation) The other patients with low blood pressures exhibited them, for the most part, for only short periods. Dr. Aub, seeking to investigate shock, was unable to find a patient with a sufficiently low pressure for a long enough time during the first night to make study worth while. Blood pressures were recorded during this time in all except two patients (Cases 13 and 34).

In spite of the possible inadequacy of the surface area formula when it is applied to burns of the head and scalp, this formula has much to recommend it. It is true that different degrees of burn may result in different amounts of edema but it is still true, roughly, that the amount of plasma fluid lost from the circulation into the tissue spaces is proportional to the area of the burn. The formula is simple to calculate and can be done rapidly, facilitating the handling of many patients. No blood determinations are necessary and it can be applied when laboratory facilities are not available. The complicated formulae of Harkins,[1] and Elkinton, Wolff and Lee[2] are not satisfactory merely because laboratory determinations and calculations are necessary in order to apply them.

There is a fundamental difficulty to the use of these formulae and also to that of Black. These three formulae tell at the specific moment the blood determination is made how much plasma is required to bring the plasma volume back to normal within a short interval. They do not allow for the amount of plasma that will leak out of the circulation over the ensuing hours. If one of these formulae is applied soon after the burn, when the patient has just entered the hospital, and but little hemoconcentration has occurred, an inadequate amount of plasma will be given. On the other hand, if the formula is applied when the maximum edema has already occurred, an unnecessarily large amount of plasma may be injected, for at that time the rate of plasma loss is diminished. Any formula made on a given blood determination must also take into account the expected loss in the hours to come and this can only be estimated on the basis of the surface area burned. A combination of the two methods is the best.

A difficulty which was partly anticipated but not adequately solved in these patients was the problem of the amount of plasma and intravenous therapy required by a patient with pulmonary damage. After the arrival of the first 15 patients it was obvious that some type of pulmonary pathology was present. At first sight, it was thought that there must have been an explosion and that the pulmonary damage was due to the blast. The intravenouses of saline and glucose solutions which were already running into the patients were slowed to a minimum while awaiting delivery of the plasma from the bank. This was done in an effort to prevent the appearance of pulmonary edema in the damaged lungs.* Already several casualties,

* Both sodium chloride and glucose are freely diffusible through the capillary wall in contrast to the plasma proteins which are only partially or slowly diffusible. In the area of a burn or chemical inflammation, the capillary permeability is increased and plasma proteins pass out more freely into the extracellular spaces along with the water and electrolytes to form the edema fluid. Saline or glucose solutions, by raising blood pressures in burned patients, tend to wash more plasma protein out into the area of injury and increase the edema. Since only a portion of the plasma proteins leak out of the capillary, an injection of plasma is more efficient than saline in maintaining blood pressure in burn shock and if given slowly will not cause as rapid a formation of edema.

obviously suffering from anoxia, had died within minutes after their arrival. As casualties arrived who were able to serve as reliable witnesses, it became clear that there had been no explosion, that only irritating fumes and heat were the cause of the pulmonary inflammation.†

In spite of the early signs of pulmonary damage, plasma was given to most of the patients. Each patient was watched carefully and it was withheld from those who, on the basis either of the mildness of their surface burns or lack of hemoconcentration, apparently did not require it. With the progression of pulmonary signs, however, more caution was exercised. After three patients had died with signs of pulmonary edema the policy of allowing a certain amount of hemoconcentration to persist was resolutely adhered to in all patients with lung damage. The hematocrit readings were maintained around 50 per cent.

Whether the dehydration regimen was of benefit is questionable. It was not sufficiently severe to eliminate kidney function and perhaps was of no detriment. On the other hand, four more patients died with signs similar to those of the earlier three. In three of these latter patients, postmortem examination revealed damage incompatible with life, due to tissue damage in the bronchioles rather than to edema. It is still an unsettled point but if we were faced with the same condition again we would probably allow a little hemoconcentration to persist throughout the period of progressive pulmonary signs.

Normal kidney function was maintained in all but three patients in spite of the hemoconcentration which was allowed to the patients with pulmonary complications. Normal kidney function is assumed when the blood nonprotein nitrogen was within normal limits, the urine volume adequate, and the disappearance of hemoglobinuria and albuminuria at the end of two weeks. No renal function tests were performed.

The nonprotein nitrogen of the blood was determined daily from the second through the fifth day in all patients who remained in the hospital, and then every other day or as indicated. Nonprotein nitrogen values above normal were recorded on six patients. In one patient (Case 38) who vomited nearly everything taken by mouth for the first six days, abnormal nonprotein nitrogens of 51 and 62 mg. were recorded on the third and fourth days. In two of the patients who died on the third day (Cases 25 and 27) the nonprotein nitrogen rose just before death to 64 and 78 mg. These are the three

From the same point of view, the physiologic saline solution used in equal volume to dilute the plasma was omitted after the first 36 hours. Fifty per cent glucose was substituted, 50 cc. for each 150 cc. of plasma, in order to maintain the free flow of the plasma. (The flow of undiluted plasma is sluggish.)

† The similarity of the pulmonary signs encountered in this disaster to those of the Cleveland Clinic fire of 1929, was not at first apparent. We had thought of that catastrophe as unique and that with the change in chemical composition of roentgenographic films, similar irritating poisonous nitrogen gases would not again be encountered in civilian life. The clinical course of these patients was also comparable to that seen in soldiers following phosgene inhalation in War I.

patients considered to have had diminished renal function. Two of these three patients had additional signs of abnormal kidney function. Case 38 showed albuminuria and Case 27 both albuminuria and massive hemoglobinuria. In Case 25 the urine findings were normal.

The other three patients in whom an elevated nonprotein nitrogen was recorded were Cases 4, 8, and 36. In Cases 4 and 36 the nonprotein nitrogens were elevated on a single occasion, 62 and 44 mg., respectively, on the fourth day. The hematocrit and serum protein determinations on

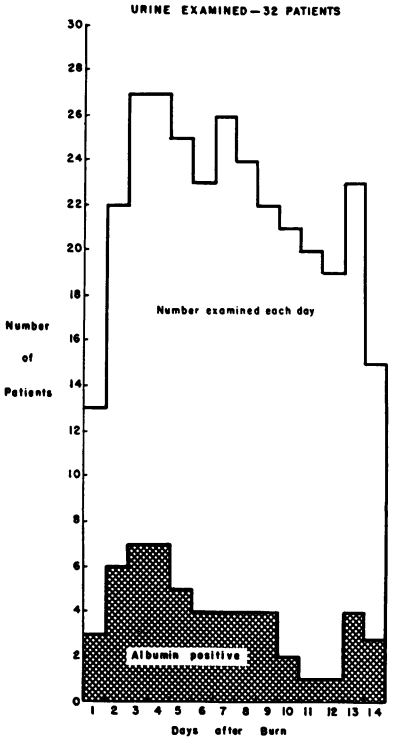

FIG. 43.—The occurrence of albuminuria in 32 patients.

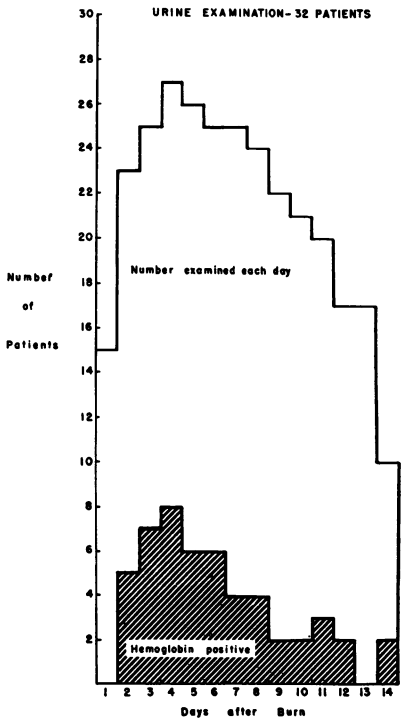

FIG. 44.—The occurrence of hemoglobinuria in 32 patients.

both of these patients were normal on that day. The final abnormal nonprotein nitrogen reading was 51 mg. in Case 8 on the seventeenth day; the hematocrit was 35 per cent and the serum protein 7.3 mg. The patient had received a transfusion the day before and received another on each of the next two days because of the low oxygen carrying capacity of the blood. In none of these three patients were there other signs of abnormal kidney function such as albuminuria, hemoglobinuria or diminished urine volume.

Albuminuria occurred in 12 patients, see Figure 43. This includes one of the patients who died. No patient showed albuminuria after the second week. It is noteworthy that the period of albuminuria coincides with the period of resorption of edema of the burns. It cannot be con-

cluded, however, that the protein of the edema fluid is necessarily excreted by the kidney as albumin, for several of the patients with massive edema exhibited no albuminuria.*

There was no absolute correlation between the albuminuria and the type of lesion. It appeared in six of the nine patients surviving with extensive burns and in one who did not. It was found in the girl with pulmonary damage and no external burns (Case 6), and in three patients with minor burns, one of whom was jaundiced. It also occurred in a man with moderate burns and pulmonary damage.

Hemoglobinuria was recorded in nine patients. In one who showed a mild degree it was probably caused by the sulfadiazine, for there were concomitant crystals, and this patient alone of the nine did not show albuminuria. In the other eight, no sulfadiazine crystals appeared during the period of hemoglobinuria. In these eight the time incidence was much the same as that of the albuminuria (Fig. 24). Five of the eight had massive hemoglobinuria; the urine was grossly dark brown to almost black. One who had it (Case 27) died on the third day. The other three showed only slight to mild amounts of hemoglobinuria and it is possible that in these the sulfadiazine may have been the cause except that the hemoglobinuria ceased even though the sulfadiazine was continued. Since but one of the group died and none of the surviving patients has shown any clinical evidence of impairment of renal function, hemoglobinuria *per se* does not necessarily result in renal damage.

It is probable that the hemoglobinuria in the patient who died was a coincidence rather than a contributing cause of death. At postmortem examination of this patient the kidneys were found to be congested with occasional petechial hemorrhages, but there was no evidence of renal damage.

Experimental evidence is accumulating to show that the liver plays an important rôle in the body's compensation to shock. An examination of liver function, therefore, following a shocking procedure, such as a burn, may be of importance in determining the character of a patient's response. Measurement of the prothrombin time was made on all patients on the third and fourth day, and subsequently in a few; in only three patients was the time prolonged. In one man who was severely burned (Case 11), on the fourth day the clotting time was 30 seconds, that of the control 20. These identical findings were recorded on Case 32 on the same day; on the following day she was jaundiced with a van den Bergh of 7.3 mg. The

* The coincidence of albuminuria and resorption of edema is a strong point in favor of the protein of the edema fluid being the source of the albumin. Dr. Zamecnik, at this hospital, has determined increased peptidase activity in human bleb fluid from burn blebs and in lymph flowing from the burns of dogs. Peptidases might alter the proteins of the edema fluid in such a way that they would be excreted by the kidney rather than reutilized. That the greater portion of the extravasated protein is made use of in the organism rather than excreted is proven by the decreasing excretion of nitrogen by the kidney during the period of resorption of edema. (See Nitrogen Balance under Metabolic Observations)

third patient with an abnormal prothrombin was Case 27, who on the third day, the day of death, had a time of 36 seconds, the control 24.

The patient recorded above with the elevated van den Bergh was the sole patient exhibiting jaundice. She had had a severe and prolonged anoxia resulting in damage to the central nervous system. The initial attack of jaundice disappeared completely in a few days but a month later, when she was receiving no sulfadiazine, she had a recurrence of jaundice with a palpable enlargement of the liver. This attack also subsided but not until after two weeks. The origin of this jaundice and hepatitis was undetermined. It can be postulated that it was initiated by prolonged anoxia.

Hemolysis was observed in only one patient (Case 34). She was extensively and deeply burned with large areas of charred skin. She died on the second day. The origin of such hemolysis is not clear. It is possible that it is the result of the actual heating of the blood present in the tissues at the time of the burn.*

Intestinal ulceration and bleeding are common sequelae of burn and other forms of shock. The origin of the lesions which give rise to the bleeding is not clear. It is possible that they are the result of anoxia of the mucosal surfaces due to capillary stasis. The stasis may be due to hemoconcentration with increased viscosity of the blood or to diminished blood flow following arteriolar constriction. Arteriolar constriction and diminished blood flow are known to occur in various parts of the body as compensation for the diminished circulating blood volume and are an effort on the part of the body to diminish the capacity of the vascular bed to make up for the shortage of available blood volume.

In either case the incidence of intestinal ulceration and hemorrhage might be considered an index of successful shock therapy. Figure 45 shows the number of stools with a positive guaiac test. None of the stools was grossly bloody or tarry. It is interesting that Case 38, with the prolonged vomiting, did not show blood. Those which were positive for blood were found in patients with all of the different types of lesions. The largest amount of blood recorded was in Case 20, who showed a +++ test on the seventh day. At this time the hematocrit was below normal and whole blood transfusions were subsequently required. She had extensive deep surface burns and it was not believed that the loss of blood in the intestinal tract significantly contributed to the progressive anemia.

An unexpected finding of interest was the occurrence of alkalosis in two patients. On both the third and fifth days, an arterial puncture was done on Case 6, the young girl with pulmonary lesion and no surface burns. The p_H's were 7.63 and 7.40, and on the first blood the CO_2 was 30.3 m.eq.,

* In the experimental laboratory we have learned to associate hemolysis with the severity of the burn.[3] Hemolysis is not encountered in dogs with hot water burns of the extremities when the temperature of the water is less than 100° C., or when at 100° C. it is applied for 15 seconds or less. At 100° C. it appears if the burn is for 20 seconds, and invariably if the burn is 30 seconds or longer.

and the oxygen content 17 vols. per cent. On the second blood, the sodium was depressed at 138.6 m.eq., whereas the other findings were normal: Total base 152.5 m.eq., calcium 9.0 mg., chloride 100 m.eq., phosphate 4.3 mg., phosphate 4.3 mg., and hemoglobin 12.7 Gm.

A second patient (Case 13) with both extensive severe skin burns and moderately severe pulmonary complications, showed an alkalosis as well as an anemia on the fifth day An arterial puncture was made to determine the oxygen content because of the falling hematocrit and progressive anemia.

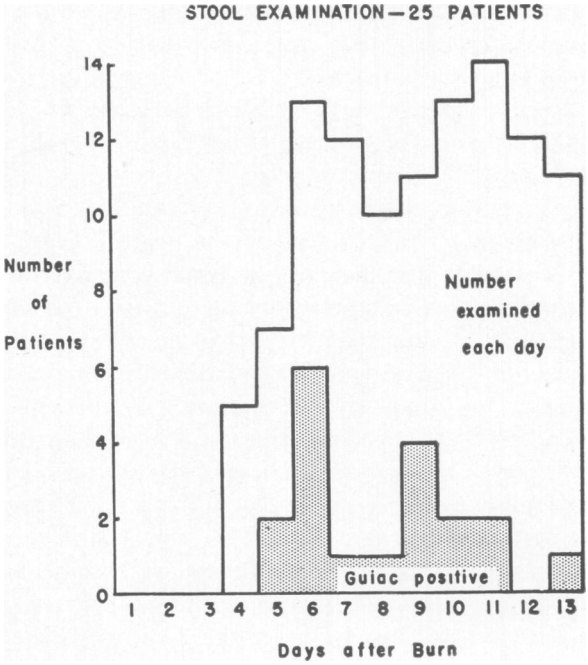

FIG. 45.—The occurrence of blood in the stools of 25 patients.

The hematocrit was 38 per cent, hemoglobin 9.4 Gm., and p_H 7.47, nonprotein nitrogen 24 mg., the total base 147 m.eq., sodium 133 m.eq., calcium 9.3 mg., chloride 97 m.eq., CO_2 content 28.5 m.eq., phosphate 1.7 mg. The phosphate was low presumably because the patient had eaten recently. The oxygen capacity was 14.6 vol. per cent, content 13.1 vol. per cent, or a saturation of 89.8 per cent.

The alkalosis in these patients was due presumably to the sulfadiazine therapy,[4] and not to the pulmonary complication. For the probable origin of the progressive anemia, see below under *Maintenance of Nutrition.*

Chemotherapy.—Chemotherapy to effect bacteriostasis is an integral part of the modern treatment of burns. At the moment, the sulfonamide preparations prevail; unfortunately, they occasionally lead to untoward results and disturb organ function and metabolism. Since the maintenance of normal bodily function is part of good shock therapy, any discussion of the treat-

ment of shock in burns must needs include chemotherapy. It has been pointed out above that sulfonamide therapy leads to a loss of base and to alkalosis but this is apparently of little import. It is the kidney and liver damage which occasionally occur even without overdosage which are of greatest significance.

The relation of infection to shock in burn patients has been but little explored scientifically. Our present clinical impression is that infection is often culpable. It is possible that the shock, even as soon as in the late hours of the first day, is in part due to the toxemia of bacterial infection. Certainly in later days infection supersedes in responsibility all other factors. The malnutrition and anemia (see under *Maintenance of Nutrition*) are almost certainly of infectious origin.

There is also a reciprocity between shock and infection. In shock, due to a disproportion between the available circulating blood volume and capacity of the circulation resulting in decreased blood flow to tissues, anoxia inevitably develops. It is well known that certain organisms, including the *beta* hemolytic streptococci, multiply faster in even slight degrees of anoxia. In burn wounds, therefore, in which any degree of anoxia exists, organisms multiply more rapidly and infectious toxemia develops relatively early.

Such thoughts only emphasize the importance of minimizing bacterial contamination of the burn wounds by immediate coverage of the surface.*

Maintenance of Nutrition.—In the treatment of burn shock every effort should be made to administer the necessary fluid and protein through the gastro-intestinal tract. Patients with less than ten per cent of the body surface burned, particularly if mildly, and if they are not nauseated or vomiting, may be treated by this route. They should drink readily digestible fluids with a high protein content. Milk and milk products, high protein bouillons with amino-acids added are such fluids. Warning should again be made that if there are deep burns of the face and scalp, particularly if there are acute pulmonary lesions as well, there may be an unexpectedly great loss of plasma volume and intravenous plasma therapy may be required. Ten of the patients, some with mild burns, and some with pulmonary damage only, were treated entirely by mouth.

High protein therapy by mouth is not sufficient. A caloric intake sufficient for maintenance is advisable. It is probable that a moderate carbohydrate intake is required for normal liver function.

Attention to the necessary accessory food substances is also imperative. All of the patients received large doses of the vitamins, both as natural and synthetic substances, from the first day. In some, these substances had to be given intravenously. It is to be remembered that patients with severe burns, even with minimal infection, have fevers, that their metabolic rates

* The availability of sulfonamides to the burn wound has been considered in a previous paper on the surface treatment. Sulfonamide levels in bleb fluid were recorded on five patients (Cases 17, 19, 20, 28, and 38). Levels, together with the simultaneous blood levels, are available in the protocols.

are, therefore, elevated, and their requirements both for total calories and accessory substances are increased. For the patients with more active infection this is the more true.

None of the patients developed clinical signs of a vitamin deficiency. They were not weighed on entry but of the 11 patients with severe burns who survived, almost all lost some weight, and two lost a very considerable amount (Cases 11 and 13).

Constant attention was paid to the development of the initial signs of anemia. None of the patients with second degree burns developed clinically significant anemia and none received, therefore, a whole blood transfusion except the woman in whom anoxic damage to the central nervous system occurred. Eight of the ten patients with third degree burns, who stayed at this hospital until healed, received transfusions for anemia. In three, one transfusion sufficed. Another three patients received three, four and five transfusions each. The most severely burned patient to survive (Case 13) received, in all, 25 whole blood transfusions of 500 cc. With this latter patient we faced difficulties:

> Her burns were so extensive and the change of dressings so painful that endless time was consumed in clearing the areas of dead tissue. From the fifteenth to forty-fifth days efforts were made to change all of the dressings at one time, and general anesthesia was required each time the dressing was done. The patient was nauseated for each following 24 hours. The nutritional status of the patient suffered and her courage failed. Intravenous amino-acid injections as well as whole blood transfusions were given by femoral vein. (A single vein in one arm was the only other available vein in an extremity). It was not until the dressings were assigned to a single team to be done without general anesthesia for lesser areas at one time, that the patient's nutritional status improved. With the advance in general health, epithelial proliferation across granulating areas became obvious and grafting was possible.
>
> This patient presented psychotic tendencies, and it was not until a rapport was reached between the patient and Dr. Cannon and his two intern assistants that mastery of the nutritional state was achieved. The rapport was abetted by the withdrawal of other physicians who previously had had jurisdiction over aspects of her care. The importance of the psychologic factor in the production of good digestion cannot be too strongly emphasized. All too frequently, where there are many doctors, each responsible for a different aspect of the patient's regimen, the patient is unable to find one physician to whom she can turn.

Adrenal Cortical Extract.—Extract of the adrenal cortex containing the active principle of the gland has been recommended in the treatment of burn shock.[5, 6] The predominant signs and symptoms of adrenal cortical insufficiency both in man and animal are those of shock. Among other findings there are a low blood pressure, hemoconcentration, and an elevation of potassium and phosphate in the blood. Such findings are also characteristic of shock appearing after trauma, burns, intestinal obstruction and sometimes severe infection.

The problem of the relation of the adrenal cortex to burn shock has been under investigation in the Surgical Research Laboratory during the past year.

It has been found that in adrenal insufficiency in the dog there is a generalized increase in capillary permeability. This increased permeability is reversible by the administration of adrenal cortical extract.[7] In the dog there is also an increase in capillary permeability in the experimental burned area as has been demonstrated by Field, Drinker and White,[8] (1931), and more recently by Glenn, Peterson and Drinker[9] (1942). In our laboratory this increase in permeability has been shown to be localized to the region of the burn.[10] Only rarely does an increase in the nonburned area develop following prolonged shock. Efforts to decrease this abnormal permeability by large doses of adrenal cortical extract have failed. Although under different experimental conditions it might be possible to influence the abnormal permeability induced by a mild burn, certainly the adrenal cortical hormone, judged by these experimental results, would appear to have little practical usefulness in burn patients.

From time to time, in this hospital, selected patients with burns have been treated with adrenal cortical hormone in the effort to evaluate this substance. No unequivocal benefit has been obtained from its use. Two of the patients of the Cocoanut Grove were selected for adrenal cortical therapy (Cases 34 and 27). Both of these patients had extensive surface burns and pulmonary injury.

On the afternoon of the first day, when it was clear that Case 34 had severe pulmonary damage, adrenal cortical extract (Upjohn) was started; 50 cc. were given intravenously over a one-hour period. The patient's blood findings before and after receiving the extract are given in Figure 46. She had already received eight units of plasma, and only a minor amount of hemoconcentration had occurred. She was selected for extract therapy in the hope of decreasing pulmonary edema by reducing the capillary permeability in the pulmonary bed.

The patient died six hours after receiving the extract. The course had been progressively downhill, with increasing anoxia in spite of oxygen administration. There was no clinical evidence that the patient had benefited from the extract. Admittedly, the patient's disease was profound and this was a rigorous test for any mode of therapy.

The second patient (Case 27) was also started on extract therapy on the first day, 14 hours after the fire. The blood determinations, before and after

CASE 34

Date	Time	Hemat. %	Pl. Prot. Gm. %	Na m.Eq/l	Cl m.Eq/l	Therapy
11/29/42	2: A.M.	51				
	5:	50	6.8	139	103	Plasma 3 units
	10:	52	7.6			Plasma 3 units
	4: P.M.	51	7.0			Plasma 2 units
	5:25					ACE started
	6:25					ACE 50 cc. finished
	10:	54	7.0	102		
11/30/42	12:50 A.M.		DIED			

FIG. 46.—Adrenal Cortical Extract (ACE): Schedule of administration together with plasma injected and blood findings in Case 34.

extract, are given in Figure 47. Before and during the extract therapy the patient received eight units of plasma. Over a period of 14 hours, 70 cc. of extract were given. She died 35 hours after the last injection of extract. During that period she received an additional five units of plasma. The nonprotein nitrogen which was 28 mg. at the time of administration of the extract rose to 90 mg. before death.

This was another severe test for adrenal cortical extract. The patient had extensive deep surface burns and pulmonary damage; anoxia persisted in spite of an oxygen tent. This patient, too, was chosen to treat with extract because of the pulmonary lesion, in the hope that the extract would diminish capillary permeability in the lung bed and thereby reduce the edema. There was no evidence either during or subsequent to the administration of the extract that the edema was less or the aeration of the blood better.

The difficulty of clinically evaluating such a substance as adrenal cortical hormone in the therapy of burns or other forms of shock is apparent from the experience with these two patients of the Cocoanut Grove disaster. There were other patients with apparently as severe pulmonary injury, or as extensive surface burns, who survived without the administration of adrenal cortical extract. Had the two patients to whom the extract was administered survived, it would have been as wrong to ascribe their survival to the adrenal hormone as it would be to incriminate the hormone as the cause of their death. There is no clinical evidence that the hormone in any way influenced the course of the disease.

CASE 27

Date	Time	Hemat. %	Pl. Prot. Gm. %	N.P.N. mg. %	Cl m.Eq/1	K m.Eq/1	Diazine mg. %	Therapy
11/29/42	2: A.M.	56						Plasma 1 unit
	10:	56	8.1					Plasma 1 unit
	12:40 P.M.							ACE started
	2:45							Plasma 2 units
	3:30							ACE 50 cc. finished
	4:	47	6.4			5.1		Plasma 2 units
	10:	45	6.2					Plasma 2 units
11/30/42	2:15 A.M.							ACE started
	2:45							ACE 20 cc. finished
	6:	43	5.8					
	2: P.M.	44	5.9	28	102.7		8.2	
	8:45	42	5.3					Plasma 2 units
12/1/42	7: A.M.	35	5.6	78	113.9		7.0	Plasma 2 units
	12:15 P.M.							Plasma 1 unit
	1:55		DIED					

FIG. 47.—Adrenal Cortical Extract (ACE): Schedule of administration together with plasma injected and blood findings in Case 27.

CONCLUSIONS

The pulmonary lesion in the casualties of the Cocoanut Grove disaster was unexpected, and complicated the care of shock. Since such lesions may occur in civilian as well as military disasters, it is well to be prepared to meet them. The treatment of burn shock, usually a straightforward problem of maintaining an adequate plasma volume, had to be modified in an

effort to prevent excessive pulmonary edema. Anoxia, not ordinary surgical shock was the primary concern.

It was fortunate that a treatment of the burn surface had been chosen in advance which permitted a maximum of attention by the personnel available to the problem of shock. Plasma therapy was prompt and effective. There were no deaths in the first 12 hours. The seven deaths that occurred took place within 13 to 62 hours and were the result of the pulmonary complication.

An effort was made to diminish the edema in the damaged lungs by allowing a mild amount of hemoconcentration to persist.

Massive edema, out of proportion to the surface area involved, may occur beneath deep burns of the face and scalp. The use of the various formulae in computing plasma dosage is discussed.

Hemoglobinuria occurred in eight patients; one died with no anatomic evidence of renal damage. The other seven have survived with normal kidney function.

Adrenal cortical extract did not affect the pulmonary edema or the general bodily function of the two severely injured patients to whom it was administered.

REFERENCES

1 Harkins, H. N., Lam, C. R., and Romence, H.: Plasma Therapy in Severe Burns. Surg., Gynec. & Obst., **75,** 410, 1942.

2 Elkinton, J. R., Wolff, W. A., and Lee, W. E.: Plasma Transfusion in the Treatment of the Fluid Shift in Severe Burns. ANNALS OF SURGERY, **112,** 150, 1940.

3 Cope, O., Mixter, G., Jr., and Graham, J. B.: To be published.

4 Beckman, W. W., Rossemeisl, E. C., Pettengill, R. B., and Bauer, W.: A Study of the Effects of Sulfanilamide on Acid-Base Metabolism. J. Clin. Invest., **19,** 635, 1940.

5 Rhoads, J. E., Wolff, W. A., and Lee, W. E.: The Use of Adrenal Cortical Extract in the Treatment of Traumatic Shock of Burns. ANNALS OF SURGERY, **113,** 955, 1941.

6 Scudder, J., and Elliott, R. H. E., Jr.: Controlled Fluid Therapy in Burns. South. Med. & Surg., **104,** 651, 1942.

7 Cope, O., Moore, F. D., Mixter, G., Jr., and Graham, J. B.: To be published.

8 Field, M. E., Drinker, C. K., and White, J. C.: Lymph Pressures in Sterile Inflammation. J. Exper. Med., **56,** 363, 1932.

9 Glenn W. W. L., Peterson, D. K., and Drinker, C. K.: The Flow of Lymph from Burned Tissue: With Particular Reference to the Effects of Fibrin Formation upon Lymph Drainage and Composition. Surgery, **12,** 685, 1942.

10 Cope, O., Moore, F. D., and Tobin, L. H.: To be published.

A NOTE ON THE BLOOD BANK

LAMAR SOUTTER, M.D.

FROM THE SURGICAL SERVICES AT THE MASSACHUSETTS GENERAL HOSPITAL, BOSTON, MASSACHUSETTS

A BLOOD BANK is a requisite for the efficient handling of patients in a disaster. In the first place it is economical. In the second place, with burn casualties particularly, it is imperative to feel free to administer all the plasma necessary. There need be no restraint in the use of frozen plasma. Dried