Burns and their treatment : including dermatitis from high explosives / J.M.H. MacLeod.

Contributors

MacLeod, J. M. H. (John MacLeod Hendrie), 1870-1954.

Publication/Creation

London : Henry Frowde [and Hodder & Stoughton] [at Oxford University Press], 1918.

Persistent URL

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BURNS AND THEIR TREATMENT

J. M. H. MACLEOD

OXFORD
WAR PRIMERS

BURNS AND THEIR TREATMENT

PUBLISHED BY THE JOINT COMMITTEE OF
HENRY FROWDE AND HODDER & STOUGHTON
AT THE OXFORD PRESS WAREHOUSE
FALCON SQUARE, LONDON, E.C. 1.

BURNS AND THEIR TREATMENT

INCLUDING

DERMATITIS FROM HIGH EXPLOSIVES

BY

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LONDON

HENRY FROWDE HODDER & STOUGHTON

OXFORD UNIVERSITY PRESS 20, WARWICK SQUARE, E.C.4

1918

PRINTED IN GREAT BRITAIN BY
RICHARD CLAY AND SONS, LIMITED,
BRUNSWICK STREET, STAMFORD STREET, S.E. 1
AND BUNGAY, SUFFOLK.

Dedicated to

OUR HEROIC AIRMEN

WHO IN SPITE OF CRASHES AND BURNS

STILL CARRY ON

PREFACE

It is related of Sir Andrew Clark, of honoured memory, that once a year it was his habit to contribute to the literature of medicine an exhaustive paper on some subject concerning which he was not thoroughly acquainted and which he had therefore selected for special study; and that it was in no small measure to these educational exercises that his wide and detailed knowledge was due.

A surgeon, and one of eminence in his craft, once confessed that he too had a habit of writing periodically on subjects of special interest at the moment. These writings he did not publish at the time, but placed to mature in a drawer in his desk. Once a year he looked them over with a view to publication, but on reading them again he was invariably so disappointed that, instead of sending them to the printer, he wrote the pious words "Thank God" across the corner and replaced them in the drawer.

There are many such writings which, under the normal conditions of life, would never have seen the light; and had it not been for the war, which has changed all things, the manuscript of this small book would probably have remained unprinted and have lain at rest in the oblivion of a bottom drawer.

Since hostilities began there have come under my care at the hospitals of the Royal Flying Corps cases of the most severe and extensive burns, and in the skin department of Charing Cross Hospital, especially in the early days of the war, cases of more or less acute dermatitis due to the making and handling of high explosives. It was to extend my own knowledge of the treatment of such affections that this manuscript came to be written.

The treatment of burns has undergone a veritable revolution during the last few years. The old-fashioned methods with greasy applications and occlusive dressings have given way to a more rational and "open method" of treatment, whereby dressings are largely avoided, and the terrible ordeal of pain associated with their removal, which did more to weaken the patient with an extensive burn than did the actual pain of the burn itself, is rapidly becoming a thing of the past.

In the publication of this small volume I can only hope that, notwithstanding its defects, it may be of equal service to the reader as the writing of it has been to the author.

In conclusion, I have to thank the Ministry of Munitions for the facilities afforded me for the study of cases of dermatitis due to high explosives, and the Publishers for their unfailing courtesy.

11, HARLEY STREET, W.,
January, 1918.

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CHAPTER I

BURNS FROM HEAT

Introduction

Burns due to excessive heat may be caused by fire, boiling liquids, steam, highly inflammable liquids such as petrol, benzine and turpentine, molten metals, superheated air, gas explosions, or any other means by which intense heat may be produced and may act on the tissues.

Burns from corrosive liquids correspond closely with burns from heat, but as they have certain peculiarities and are to some extent characteristic of the corrosive which produces them they will be described separately.

The term "burn" is generally reserved for the lesion caused by the action of dry heat on the tissues, while "scald" is employed to denote that due to

the action of moist heat. A burn is caused by dry heat of about 140° F.[1] and upwards, and a scald by moist heat at 125° F. and upwards. The highest temperature of moist heat which the hand can bear is about 120° F., and anything above that is liable to produce a scald.

From a practical point of view, in the description of burns the manner of their causation is immaterial, and burns and scalds, though differing widely in the agents which produce them, are so similar in their clinical features as to warrant their being described together.

Scalds are usually less severe than burns, though the area involved is generally more extensive, and statistics show that the mortality from them is considerably less than that from burns due to dry heat. In the Registrar-General's return for England and Wales in 1915, out of 993 fatal burns in males 568 were due to dry heat and 425 to scalds, while in females the proportion of fatal burns to scalds was as 1,226 to 232.

The characters of the lesions produced by burns are dependent in severity on the degree of the temperature, the extent of the area exposed, and the duration of the exposure. In both burns and scalds the gravity is proportionate to the extent rather than to the depth of the injury, and it has been repeatedly observed that a burn or scald of considerable depth and severity but of limited area may have far less

[1] To convert degrees Fahrenheit into degrees Centigrade deduct 32 degrees, multiply by 5 and divide by 9.

serious consequences than a more superficial burn in which the area involved is greater.

Classification.—In France and Great Britain it is customary to classify burns, after the manner of Dupuytren, into six degrees, according to the depth of the burning, while in America a simpler classification into three degrees is generally adopted. These classifications, though arbitrary and imperfect from the frequency with which burns of more than one degree occur in the same case, are of some value in simplifying the description and in drawing special attention to the maximum depth to which the burn has reached and to the precise tissues which have been most severely damaged.

The classification of Dupuytren, which will be employed here, is briefly as follows :—

1. Burns of the first degree are caused by a temperature of about 140° F., involve only the superficial layers of the epidermis, and are characterised by erythema, slight œdema, smarting, and tenderness.

2. Burns of the second degree are caused by a temperature of 160° to 210° F., and involve the whole thickness of the epidermis as far down as the papillary layer of the corium, which layer is left intact. They are characterised by the formation of vesicles or bullæ, more marked inflammation and œdema, and considerable pain.

3. Burns of the third degree are caused by a temperature greater than 210° F., and involve, not only the epidermis, but the upper layers of the corium.

In them the burned tissue becomes devitalised and forms a brownish, leathery patch known as the "eschar."

4. Burns of the fourth degree are caused by a more prolonged exposure to a temperature similar to that responsible for burns of the third degree, or to a higher temperature. They are characterised by complete destruction of the epidermis and corium down to, and sometimes including, the subcutaneous tissue.

5. Burns of the fifth degree involve the skin and the underlying subcutaneous tissues and muscles, and may reach down as far as the bone.

6. Burns of the sixth degree are characterised by the carbonisation of the whole thickness of the part, including the bone.

Symptoms.—The clinical features of burns and scalds will be described together under the headings of (1) local effects, and (2) general effects.

Local effects.—*In burns of the first degree* the skin is simply scorched but not destroyed, the burned part becoming red from a dilatation of the blood-vessels and slightly swollen from a transudation of fluid into the tissues. The redness, which is easily obliterated by pressure and fades gradually into the surrounding skin, appears almost immediately after the exposure to the heat and may last from a few hours to several days. When the inflammation subsides it is followed by superficial desquamation or scaliness, which disappears in a day or two, leaving

either no trace or a slight and transient pigmentation. Even if the superficial cells of the epidermis be destroyed, they are gradually replaced by new cells from the stimulation of the basal layer of the epidermis which occurs in the process of healing, and complete restoration of the skin takes place without scarring.

The affected skin is tender and there is a sensation of tingling or, in more severe cases, of burning which may amount to actual pain. This is due to the direct action of the heat on the sensory nerve-endings. The pain is transient and becomes less as the œdema increases, owing to the soothing action of the serous fluid on the injured nerve terminations.

Burns of the first degree are not associated with constitutional symptoms unless a considerable area of skin is scorched, when the pain, and possibly the fright from the burn, may cause the patient to be excited and nervous and may interfere with sleep.

In burns of the second degree the inflammation is more acute, the erythema deeper, the transudation of fluid into the skin more marked, and the burning pain more severe. Either at once or in the course of a few hours the inflamed skin becomes surmounted by groups of small vesicles which are discrete or confluent, or by larger bullæ which are irregular in outline and vary in size up to large blisters several inches in length.

The bullæ are more or less tense, and the pain associated with them varies directly with the degree of tenseness. At first they contain a clear, slightly

FIG. 1.—Burn of second degree with large bullæ.

yellowish, fluid which as time goes on becomes turbid. They are readily broken by injury or may even rupture from an increase of the exudation into them, and when the fluid escapes it dries up into a yellowish crust. Occasionally, if the bleb be protected from injury and not interfered with, the fluid in it may become absorbed and the bulla may collapse without breaking.

Should the bulla break, a raw surface is left which is bright red in tint where the papillæ are exposed, readily bleeds on the slightest injury, is extremely tender to the touch, is painful, and smarts on exposure to the air. The appearance of the floor of the blister differs according to the position in the epidermis in which it has formed. When the fluid has collected beneath the epidermis, and the floor of the blister is constituted by the papillary layer, the denuded surface is bright red in colour ; when the blister has formed partly within the epidermis, either in the situation of the granular layer or beneath it, the denuded base is less bright in tint and presents here and there a greyish film—the remains of the epidermis.

When the blister is superficial and more or less of the epidermis is preserved on its floor, healing takes place readily in from a few days to a week, and is so complete that no trace of the injury remains, except perhaps a slight pigmentation which soon disappears. On the other hand, if the bleb has formed entirely beneath the epidermis and denuded the papillary layer of the corium, or more so if the contents have been allowed to become septic and superficial ulcera-

tion has supervened, then an alteration in the texture of the healed skin or a definite scar is inevitable.

In connection with burns of this degree more or less severe constitutional symptoms may occur the intensity of which is dependent on the extent of the burn (see page 17).

In burns of the third degree the epidermis and the superficial layers of the corium are more or less completely destroyed and form the dead piece of burned skin, named the "eschar." This is ashen-grey or brownish-black in colour, occasionally presents a few abortive vesicles on the surface, is leathery in consistence and, as a rule, insensitive to touch. The skin around it may be in the condition of a burn of the second degree and present vesicles or bullæ, while beyond that again a zone of inflammation is generally present which may end fairly abruptly or may fade into the neighbouring skin. At first the eschar is adherent to the underlying tissue, but in the course of a few days to a week a painful inflammation sets in and suppuration begins at the edges which gradually spreads in beneath the eschar, separates it, and causes it to slough off in about a fortnight.

In the case of burns produced by superheated air at about 400° F., the immediate effect is to cause the skin to crackle and become blanched from ischæmia, while further exposure leads to absolute charring, the degree of penetration of the charring being dependent on the time of the exposure. These effects have been studied in detail in connection with the hot-air apparatus employed in the treatment of lupus; this

apparatus consists of a metal tube about a quarter of an inch in diameter with a nozzle at one end, while at the other end is fitted an indiarubber tube with an air reservoir and a rubber bulb like those of a Paquelin's cautery ; beneath the tube is fixed a Bunsen burner by which the air pumped through the tube can be heated to a temperature of 400° F., and even higher.

At the time of the burn, and for about forty-eight hours afterwards, the pain may be so great as to be almost unbearable, but this, as a rule, gradually subsides. It returns, however, more or less acutely with the secondary inflammation and the separation of the eschar. In extensive burns accompanied by severe shock, the pain is often comparatively slight, and even may not be felt, but this is a serious sign, as it generally points to a fatal issue.

After the eschar comes away a raw surface is left, covered with granulations and moist from a semi-purulent discharge. Healing then gradually sets in with a new growth of epidermis, in the form of a fine film which spreads in from the edges and from small foci of epidermis which have escaped the burning and appear dotted here and there over the granulating surface and which are either the remains of the basal layer or of pilo-sebaceous follicles. The islets of epidermis spread and coalesce into irregular patches which finally join up with the new growth from the edges.

The scar which results is pinkish-red in colour at first and remains so for a considerable time, but eventually becomes whitish and opaque. It is

usually supple and of a fairly normal texture, but is smooth and glossy owing to the absence of hair

FIG. 2.—Atrophy of the skin following burn from explosion.

follicles and sweat pores. Where the scar has been formed by the coalescence of small foci, it may be

uneven on the surface and assume the appearance of a meshwork of small cicatricial bands including smooth islands of protruding scar tissue. The majority of the scars show a tendency to contract for several months and then remain permanent. This contraction, if marked, causes the skin immediately around to present a peculiar puckered appearance, and may lead to ectropion, a distortion of the mouth, or other deformity.

In association with burns of this degree both the early shock and the general reaction caused by the absorption of toxic substances may be considerable.

In burns of the fourth degree not only the skin is involved to its whole depth but, as a rule, the destruction reaches the subcutaneous tissue. The eschar is brownish-black in colour and completely devitalised, the pain associated with this degree of burning being situated in the inflammatory zone around it, while the eschar itself is quite insensitive owing to the destruction of the nerve terminations. The charred skin is surrounded by a red inflammatory halo, which may be of importance from a medico-legal point of view as it only occurs in burns which have been inflicted during life.

In the course of a few days pus appears at the edges and in ten days or a fortnight the eschar gradually separates, leaving a raw, excavated wound, the base of which is covered with moist granulations. Where the suppuration has been excessive, purulent absorption may take place, causing the neighbouring glands to become enlarged

and painful and sometimes resulting in general symptoms of septic poisoning. Of the various micro-organisms which have been found in the

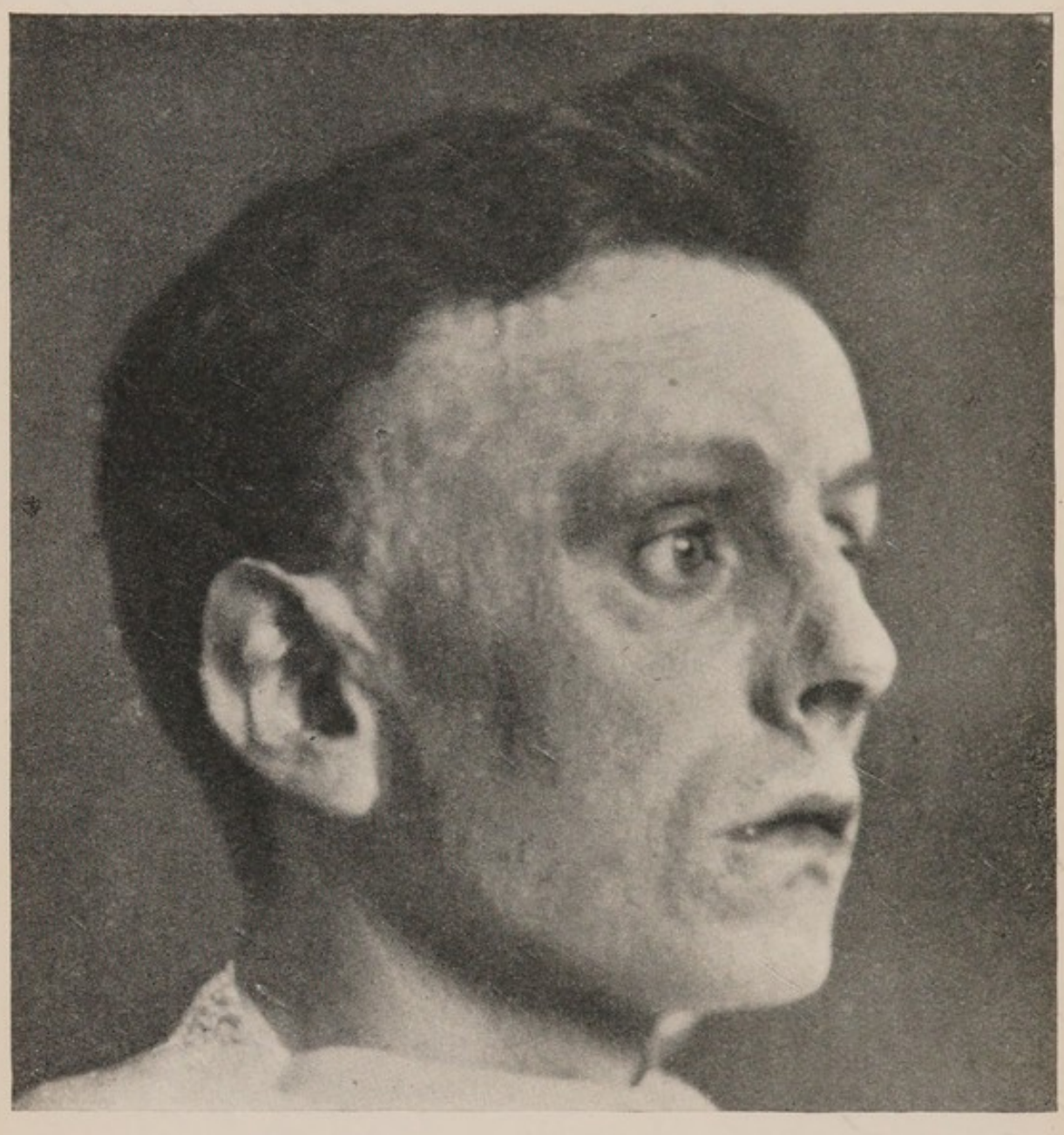


FIG. 3.—Scarring from extensive burn of second and third degrees due to petrol.

discharge the most frequent have been *Streptococcus pyogenes*, *Staphylococcus aureus*, and *Bacillus pyocyaneus*.

The raw surface heals slowly, for the new growth of epidermis has to take place entirely from the edges, as the epidermal cells of the sloughed area have been absolutely destroyed. It has been estimated that the new growth occurs at the rate of about an eighth of an inch per week, and consequently if the raw surface be large it may be months before it is completely covered. Healing is delayed should suppuration be excessive, owing to the more or less deep ulcerations which may result; it is also hindered where the granulations are exuberant and these must be restrained, either by suitable astringents or by continuous pressure exerted by a dressing. The healing may be facilitated by early grafting, which may be resorted to even in the presence of a semi-purulent discharge, as this is no deterrent to the grafts holding.

The scar from burns of the fourth degree is invariably uneven and may be unsightly; it is irregular in outline and not infrequently stellate, with processes extending for varying distances into the surrounding tissue. As a general rule, it may be said that the more rapid the healing the better the type of scar which will result, and that where healing is delayed from some reason or another it is liable to be associated with a more or less excessive formation of scar tissue, which, on contracting, may lead to impairment of movement or marked deformity.

As time goes on the scar may become hypertrophic or keloidal from a definite new growth of fibrous tissue in the skin. This development appears first

as a small, pinkish thickening of the scar, which gradually increases until it becomes a sharply defined ridge or tumour the surface of which is smooth and hairless and usually presents small blood-vessels ramifying over it. As a rule, the keloidal scar is painless, though occasionally it may be tender, itchy, or actually painful. The reason why certain scars from burns become keloidal is unknown ; a probable suggestion, however, is that it is the result of infection of the unhealed granulation tissue by some micro-organism which has not yet been isolated. It is also well known that certain individuals have an idiosyncrasy on account of which keloidal scars tend to follow the slightest traumatism and abrasion of the skin.

The contraction of the scar is responsible for the deformity and disfigurement which are among the most serious after-effects of burns. On the face, for example, the contraction of burn scars may drag and evert the lower eyelid, causing a continuous running of tears down the cheek and great discomfort, or the corner of the mouth may be pulled down and lead to dribbling of saliva, or the auricle may be contracted or displaced. Where the limbs are involved, permanent flexion of the joints may result, and the movements may be so limited as to render the arm or leg almost useless, or, where the burn has occurred about the axilla, union of the arm to the trunk may take place, interfering with the abduction of the arm and constituting the so-called "bat's-wing" deformity. Consequently, in the

treatment of burns every endeavour must be made to ensure healing with as little contraction as possible, as the prevention of it is far more hopeful than subsequent attempts to cure it.

Another, fortunately rare, after-effect of burns is the occurrence of malignant changes in the scar and the formation of an epithelioma. This may follow within a month of the injury in tissues which were previously healthy, but as a rule it is a much later development which occurs on an apparently healthy burn scar which has been subjected to friction or some other form of traumatism.

A well-known example of epithelioma developing on burn scars is the so-called "Kangri cancer" of Kashmir. The kangri is a small vessel containing burning charcoal which the natives carry about in cold weather and which they are in the habit of pressing against the thighs and lower part of the abdomen for warmth; this produces multiple burns followed by scars which, being irritated by the friction of the kangri and by further exposure to heat from it, frequently become malignant.

In burns of the fifth and sixth degrees where the charring extends down through the skin and subcutaneous tissue to the muscles and even to the bone, healing is impossible. If a considerable area be affected a fatal result is inevitable, but if the burn be limited to a hand, foot, finger, or toe, recovery may take place with the loss of the burned part.

Burns of this severity are comparatively rare and

FIG. 4.—Burn from explosion. Flexion deformity of fingers from healing being allowed to take place without extension.

are most liable to occur from burning phosphorus or from prolonged contact with red-hot metal.

General Effects.

The constitutional effects of burns vary with the situation of the burn and the extent of the skin affected rather than with the depth of the burn. They are more severe than the general symptoms which follow other injuries involving an equal destruction of tissue.

They may be most conveniently described under the headings of (1) Primary or immediate effects, consisting largely of shock; (2) secondary effects, from the absorption of the toxic products of the devitalised tissue and foreign proteins from the cells in the neighbourhood, from inflammatory diseases of internal organs, and from sepsis.

(1) Primary Effects.

Burns of comparatively limited extent may give rise to considerable nervous disturbance, causing the patient to be excited and hysterical and not infrequently to cry out with pain, and this may be followed by more or less prostration; those in which a considerable area has been implicated are associated with severe shock and collapse.

The degree of shock varies according to the extent of the burn, and the age, power of resistance, and general health of the individual. In most cases it

lasts from twenty-four to thirty-six hours, occasionally for forty-eight hours. The pain associated with it is less than would be expected, and even in grave and extensive burns it is often comparatively slight. In one case it may come on soon after the burn; in another, the patient may remain comparatively well during the first twenty-four hours, except for local discomfort, and then gradually succumb with severe symptoms of prostration preceded by spasms, great restlessness, and distress over the cardiac region.

The symptoms generally associated with shock are present to a greater or less degree.

The pulse is irregular and rapid—sometimes reaching 130—and may be so small that it can scarcely be felt.

The blood-pressure is low, owing to dilatation of the arteries caused by loss of control of the vaso-motor centres and the increased amount of blood which flows into the splanchnic veins in the abdomen.

The temperature is sub-normal, about 92° to 95° F., and may become so low as to be incapable of registration by the clinical thermometer. The temperature of the skin is lowered, and it feels definitely cold and is moist with a clammy sweat.

The features become drawn and pinched, the respiration is feeble, the urine is scanty and may contain albumen, and the patient complains of a peculiar sinking sensation, is nauseated, and suffers from thirst.

In the majority of the fatal cases death supervenes within forty-eight hours.

(2) Secondary Effects.

(*a*) *Toxæmia.*—Should recovery from shock take place severe symptoms of an inflammatory type may supervene, due to the absorption of chemical poisons, such as foreign proteins from the injured cells or actual toxic products of completely destroyed cells. This stage comes on immediately on subsidence of the shock and may last from ten days to a fortnight until the eschar has separated. The symptoms are those of a general inflammatory reaction from intoxication, and consist of restlessness, headache, malaise, and a rise in temperature to 104° or even higher; these may be ushered in by a definite rigor but as a rule they begin more insidiously.

(*b*) *Inflammatory Diseases of Internal Organs.*—Severe burns of the head have been known to be followed by meningitis.

In burns of the trunk, the underlying internal organs are liable to be implicated, and inflammation of the membranes or organic changes in the organs themselves may supervene.

In burns of the chest, pleurisy and, more rarely, bronchitis or broncho-pneumonia may be set up.

In burns of the abdomen, the gastro-intestinal tract may be affected, and this may lead to hæmatemesis or blood in the stools; gas may accumulate in the stomach and intestines to such a degree as to impede the action of the heart and respiration and

even to displace the liver ; or the peritoneum may be attacked and more or less severe peritonitis result.

Inflammation of the duodenum may give rise to the formation of an acute duodenal ulcer, situated chiefly opposite the head of the pancreas, which may lead to serious hæmorrhage from the duodenal arteries. This complication is said to be specially common in young children, but though it may occur occasionally, its frequency and importance seem to have been somewhat exaggerated.

Inflammation may also be set up in the kidneys, evidenced by the presence of albumen and blood in the urine.

(*c*) *Septicæmia.*—About the time of the separation of the eschar and until healing is advanced there is a serious danger of septic absorption and its associated symptoms. It may be ushered in by a severe rigor, a high temperature with morning remissions, a small, fast, irregular pulse, nausea, vomiting, and occasionally by a transient erythema or scarlatiniform rash. In severe cases this may be followed by delirium, prostration, and in rare instances by capillary hæmorrhages and purpura. It is a most serious complication and may give rise to a fatal issue within twenty-four hours of its onset—death from it being rarely prolonged for more than a week and taking place in a state of profound stupor.

Septicæmia is due to a microbic invasion of the blood and tissues and may be caused by *Streptococcus pyogenes* or *Staphylococcus aureus*. Fortunately, it can be largely prevented by proper aseptic methods of treatment.

In rare instances secondary infection by other virulent organisms, such as the tetanus bacillus or the streptococcus of erysipelas, has been known to occur. Of the two, tetanus has been the more frequent complication and is particularly liable to happen in connection with burns sustained in flying when the machine has crashed to the ground and caught fire and the burn has become plastered over with mud or earth.

Cause of Death from Burns.—When burns are fatal, death usually takes place during the period of shock and within thirty-six hours of the burn.

The precise cause of death in the state of shock is obscure, as the post-mortem findings have been inconclusive ; changes have been reported from time to time in different organs, especially in the suprarenals, such as hyperæmia and hæmorrhagic infarction, but none has been sufficiently constant definitely to account for the fatal issue.

Of the various hypotheses which have been advanced to explain death from burns the following are the most important :—

1. That it is due to heart failure from paralysis of the cardiac muscle.

2. That it is due to a disturbance of the circulation from embolism or thrombosis in one of the larger arteries, such as the ascending aorta or the innominate.

3. That it is due to an actual destruction of the blood.

4. That it is the result of a serious interference with the functions of the skin owing to the extent of the burned area.

5. That it is due to an inhibition of the nerve-centres from injury to the nerve-endings in the skin and deeper organs.

Should the patient survive shock, death may supervene in the course of the first or second week from acute toxæmia, the result of the absorption into the blood of highly toxic foreign proteins from the burned tissue, which are prevented from being rapidly eliminated by the destruction of part of the excretory cutaneous surface. In this connection, experiments which have been carried out in rabbits and dogs which have died from extensive burns have shown that the blood from the burned animals, extracts of the burned tissues, and even the urine passed by the animal some time after the injury, are toxic to other animals and cause death with symptoms similar to those seen in the burned animal.

Death may also take place about the same time from acute inflammatory disease of the internal organs and membranes, such as pleurisy, broncho-pneumonia, ulceration and hæmorrhage in the gastro-intestinal tract, etc.

After the separation of the eschar, death may be caused by the absorption of septic products from the granulating surface or from its secondary effects, such as nephritis or septic pneumonia. But it is an extremely rare occurrence after the acute toxic reaction has subsided during the second week.

A further rare cause of death at a later period is sheer exhaustion from more or less continuous pain and excessive discharge from the granulating surface.

Death may also be caused in exceptional cases by secondary infection by tetanus.

Histological Changes and Pathogenesis.—The initial action of heat is to cause a dilatation of the cutaneous blood-vessels in the affected area, clinically evident in the erythema. This is followed by an exudation of serum and an infiltration of mononuclear leucocytes and small connective-tissue cells, which are responsible for the swe'ling. The serous fluid passes up between the cells of the epidermis, causing them to be œdematous, interfering with the process of cornification, and giving rise eventually to the scaliness which succeeds the erythema in burns of mild degrees.

When the heat has been more severe, the serous exudation is greater, takes place more rapidly, and, being unable to escape by evaporation on the surface, collects in the epidermis, giving rise to vesicles or bullæ. The precise position of the bulla in the skin is largely dependent on the rapidity of the exudation ; where this takes place comparatively slowly it usually collects in the epidermis itself, about the situation of the granular layer, while if it be more rapid it tends to collect entirely beneath the epidermis, forming a bulla the roof of which is constituted by the whole thickness of the epidermis and the floor by the papillary layer. The bullæ are the result of the fluid stretching, weakening,

and breaking the minute fibrils which unite the prickle-cells and of its accumulating in the spaces so formed. This process is facilitated by (1) the softening of the epidermal cells by the heat and the transformation of the moisture in and about them into steam, which, forcing its way between the prickle-cells, separates them so as to form irregular spaces and thus prepares a passage for the fluid; (2) the toxic action of the dead epidermal cells causing a positive chemotaxis and attracting more serum or even blood corpuscles into the bulla.

Extreme heat causes at first a softening of the cells of the horny layer and deeper cells of the epidermis and of the fibrous bundles of the underlying corium. This is followed by a coagulation of the protoplasm, and finally by a carbonisation of the cellular and fibrous elements and an occlusion of the blood-vessels and lymph channels to form the eschar, which may extend down to any depth in the tissues, according to the degree of the burn.

The skin in the immediate neighbourhood of the eschar shows evidences of an inflammatory disturbance with dilatation of the blood-vessels, œdema affecting the epidermis and fibrous tissue in the corium, and an infiltration of leucocytes and small, round, connective-tissue cells with a more or less marked deposit of poly-morphonuclears called forth by the toxic action of the dead cells of the eschar and possibly by septic micro-organisms situated about the devitalised tissue at the edge.

On the separation of the eschar, a more or less deeply ulcerated surface is left which heals by the organisation of the small, round cells of the cellular infiltration into new fibrous tissue which may be so abundant as to form a keloidal scar.

The scarring which results when a burn heals is dependent on the depth of the burn. It is only in burns of the mildest degree in which only erythema occurs or where, if bullæ have formed, a flooring of epidermis is left, that healing may lead to complete restoration and no trace of the injury be left. If the papillæ have been denuded, an alteration of the texture of the skin is inevitable on healing, while if the burn has led to the destruction of subcutaneous tissue or muscle, the new formation of fibrous tissue gives rise to a more or less unsightly scar which tends to contract for months.

Diagnosis.—The diagnosis of slight burns from other localised patches of erythema is usually possible from the destruction of the hairs on the exposed parts and the burning sensation associated with the redness.

In the vesicular and bullous phases, burns are easily distinguished from other bullous conditions, such as pemphigus, by the marked subjective symptoms, the definite history of the accident, and the localisation of the lesions to the burned area instead of being irregularly distributed over the cutaneous surface.

The scars from burns are not readily mistaken for scars from ulceration due to other causes, and the history aids the diagnosis. Burn scars are hairless, generally present an irregular indented border, are sometimes wrinkled, are red for a long time, are frequently irregular, and are sometimes keloidal.

CHAPTER II

BURNS FROM HEAT—(*continued*)

Prognosis.—In burns, excepting in those of slight degree, a guarded prognosis should invariably be given, for the outlook is, as a rule, much more serious than it might appear to be at first sight and, though the injury may seem to be comparatively mild and bullæ have scarcely developed, if a large area be burned a fatal issue may supervene in a few days. It may be said as a general rule that burns involving more than one-third of the cutaneous surface are apt to be followed by serious if not fatal consequences, while those involving one-half are almost invariably fatal.

In the majority of fatal cases death has taken place from acute shock within twenty-four hours. Should extreme prostration not develop within two days the prognosis is more favourable, but even when the state of collapse is safely passed there is always the danger of death from toxæmia, inflammatory disease of the internal organs, septicæmia, or exhaustion.

The prognosis is to some extent influenced by the sex and age of the patient, and statistics show that

the mortality from burns in females is greater than in males and, as would be expected, that it is heavier among children and elderly people than among those in the prime of life.

The annual ratio of deaths in females from burns averages one-third of the total deaths among females from accident, while in males it is only about one-fifteenth.

According to the Registrar-General's return for England and Wales, in 1914, out of 2,275 fatal burns and scalds, 936 occurred in males and 1,339 in females, and of these 130 were under one year, 1,428 between one and ten years, 175 between ten and thirty years, 189 between thirty and fifty years, 325 between fifty and eighty years, and 30 over eighty years.

Another factor in the prognosis is the general condition of the patient, and any debilitating influence or disease, such as alcoholism, fatigue, malnutrition, malaria, or tuberculosis, may render the individual more susceptible to the constitutional effects from a burn and increase the mortality.

The outlook is also more grave when burns occur over the great serous cavities, such as the chest and abdomen, than when the limbs alone are involved.

Time taken in the healing of burns.—The time which a burn takes to heal depends on the extent of the area involved and the general condition of the patient.

Burns of the first degree heal readily in a few days, but where the area of skin injured is extensive the

shock may be so great that considerable delay may occur before the injured person is well.

Burns of the second degree may take several weeks to heal and should suppuration occur further delay may be caused.

Burns of the third and fourth degrees usually take months to heal, and are liable to be followed by contraction of the scar which continues for months and, unless prevented or corrected, may lead to unsightly deformities, and may limit movement.

Burns of the fifth and sixth degrees, if they involve the trunk to any extent, are almost invariably fatal. Should the limbs be the seat of burns of this severity, amputation may be necessary.

Malingering.—The pain from burns is usually severe, and in consequence malingering by the wilful production of burns by heat is extremely rare, and when it does occur the burns are usually of slight degree. On the other hand, among the most common methods of malingering is the self-infliction of burns by corrosives, such as nitric and carbolic acids (see page 125).

Treatment.

The treatment of burns will be considered under the headings of: (1) General treatment; (2) Local treatment.

General Treatment.—The chief immediate danger of burns, except in those of a trivial nature and limited extent, is shock and its consequences. To overcome

this is the first aim in the treatment, and requires the most prompt, thorough, and effective measures. Though death may also take place from toxæmia or septicæmia, these occur later and give no immediate cause for alarm and, should the patient recover from the shock, they may be largely prevented by careful aseptic local treatment.

As a rule, in burns of great severity there is no time to be lost, and before attempting even to remove the charred clothes and expose the burn it is imperative to attend to the general condition of the patient.

Where severe shock is caused by the burn, the pain is usually comparatively slight; indeed, it may almost be said that the less the pain the more profound the shock. If the shock be less and the pain so great as to be almost unbearable, it may be advisable to quiet the patient by giving a hypodermic of morphia, but there is some difference of opinion as to the advisability of this procedure. It should certainly be given in cases which are obviously going on to a fatal issue, in order to render the patient's last hours as free from pain as possible, but in most other cases it is on the whole better to do without it as, when its influence wears off, although the pain may be to some extent soothed, the patient is apt to become more excitable and restless than before. In children, who do not bear it well, it should be prohibited altogether.

Where the shock is extreme it means that the blood pressure is low and the heart depressed, and in consequence morphia or opium are really contra-indicated,

as they tend further to reduce the pressure and depress the heart. It is still worse, however, to attempt to treat the shock by stimulating remedies, such as strychnine, digitaline, brandy, etc., as these only irritate the exhausted brain centres, which require rest rather than stimulation.

One of the best methods of combating the shock is by means of hot baths, either whole baths where the burn is extensive or leg- or arm-baths if a limb alone be involved. The temperature of the bath depends to some extent on the individual, some feeling more comfortable in a bath between 80° and 90° F., while others prefer a higher temperature of about 100° F.

If a whole bath be employed, the patient should be placed in as comfortable a position as possible, with someone in constant attendance to see that he does not slip down too far and to minister to his needs. The ideal arrangement is to put a water pillow at the bottom of the bath and to fix another by a webbing strap on the top of the bath for the patient to lean against and to prop up the head. The bath should be covered with a blanket, and hot water added from time to time to maintain an even temperature as indicated by a thermometer kept constantly in the water.

The patient should be placed in the bath before attempting to take off the clothes, as they are generally stuck to the burned part and any effort to remove them while dry may be extremely painful, may cause hæmorrhage, wastes valuable time, and may actually increase the shock. On the other

hand, the hot water softens the clothes, loosens them from the parts to which they adhere, and facilitates their removal.

An effort should now be made to increase the blood pressure and so to counteract the shock. This can best be done by infusions of normal saline solution either injected into the rectum, subcutaneously, or better, intravenously. For this purpose an emergency salt solution can be made by dissolving one teaspoonful of common salt to each pint of water or by employing one or other of the preparations such as soloid sal. co. (Burroughs, Wellcome & Co.), which, when dissolved in water, give a physiological salt solution.

The rectal infusion should be made as follows: A rubber catheter of suitable size is passed into the rectum, and to this is attached a rubber tube from an irrigator containing the saline solution at a temperature of 105° F. The saline is allowed to pass continuously into the rectum, which must be done slowly so that as much of it may be retained as possible. In this manner 10 to 15 pints may be infused. It is necessary, of course, to keep the solution in the irrigator at an even temperature.

If the subcutaneous method be adopted the needle may be conveniently inserted into the loose subcutaneous tissue about the sides of the abdomen, or beneath the scapula or breasts, and three or four pints of saline should be slowly introduced.

The intravenous method is the most effective of all, and is usually done into the median basilic vein,

but other veins, such as the internal saphenous or even the jugular, may be employed should the median basilic not be available. The saline should be injected slowly and continuously from a receiver, which should not be raised more than one and a half to two inches above the level of the needle. The infusion should be continued until a pint or more has been injected, when the radial pulse may begin to be felt.

Adrenaline.—The value of the infusion can be greatly enhanced by the addition to it of adrenaline. About 30 minims of the Liquor Adreninae Hydrochloricus should be added to each pint of the normal saline solution. Adrenaline has the power of raising the blood pressure by acting directly on the vessel walls and has the advantage of not putting any strain on the tired-out nerve-centres. It is most effective when employed by the intravenous method; it is useless when added to a rectal infusion, and is of comparatively little value when the infusion is given subcutaneously.

Pituitary Extract.—Pituitary extract has a somewhat similar action to adrenaline, but is less potent. It has the great advantage, however, that its effects last considerably longer than those of adrenaline—the contraction of the blood-vessels persisting for an hour or longer. It should be given by intramuscular injection of a $\frac{1}{2}$ to 1 c.c. of a 20 per cent. solution of the extract; this represents 0·1 to 0·2 gram of the fresh infundibulum of the gland.

The patient should be kept in the bath for several

hours until the general condition is sufficiently improved for him to be put to bed. While in the bath the clothes should be gradually removed, care being taken not to drag them off the charred parts, as this proceeding is apt to lacerate the wound, causing hæmorrhage and increasing pain. The bed should be warmed and a mackintosh sheet placed beneath the ordinary sheet. Under no circumstances should hot-water bottles be placed against the skin, as its resistance is so lowered that further serious burns may result. If the shock has been severe and the pulse is still feeble, the foot of the bed should be raised at least two feet higher than the head by the simple expedient of placing the foot of the bed on chairs, and if the abdomen be uninjured a many-tailed bandage should be applied around it to assist in increasing the blood pressure.

When in bed, every effort should be made to get the patient quiet, and if possible to enable him to sleep, but if the blood pressure be still low and signs of collapse persist the saline infusions should be continued. When recovery begins to take place small quantities of hot water should be given by the mouth at frequent intervals and later hot milk or beef tea may be substituted.

When the abdomen has been injured tympanitis is liable to supervene from gas collecting in the stomach and intestines, sometimes in such quantity as greatly to embarrass the action of the heart and respiration. This should be combated by the passage of a rectal tube, by an enema containing a few drops

of turpentine, or by giving a few drops of spirit of chloroform or turpentine by the mouth.

After the stage of shock has been successfully overcome the patient must be carefully watched in case toxic symptoms should supervene. Should this occur it is of the utmost importance to try to maintain the resistance and to cause the rapid elimination of the toxic proteins by the skin, kidneys, and alimentary tract by the employment of diaphoretics, diuretics, and other appropriate means.

Should septicæmic symptoms develop, every care should be taken by suitable local measures to prevent further invasion by septic micro-organisms and every effort made to increase the resistance of the patient by a stimulating *régime*. The diet should be fluid and consist essentially of easily-digested foods such as milk, beef tea, etc., while strychnine, either in the form of the tincture of Nux vomica or in hypodermic injections of the Liq. strychninæ hydrochloratis, digitaline by hypodermic injections, or iron in the form of the Tincture ferri perchloridi in doses of 15 minims every four hours, should be given internally. If the temperature be over 103° F., relief may be obtained by sponging with tepid water. Where possible, the causal organism should be isolated, a vaccine prepared, and suitable doses injected. Should this not be practicable and there be reason to believe the micro-organism to be â streptococcus, injections of a polyvalent anti-streptococcal serum or a stock streptococcal vaccine may be of benefit.

Even when neither toxæmia nor septicæmia occur,

if the burn has been extensive and accompanied by shock the patient remains in a feeble and exhausted condition for a considerable time and his convalescence is protracted. Consequently, his system requires to be built up by a generous though easily-digestible diet and a suitable tonic *régime*.

In view of the possibility and extreme danger, especially in the case of troops on active service, of burns becoming secondarily contaminated by the tetanus bacillus, it is advisable in all burns of more than the first degree to give a prophylactic injection of 1,000 to 1,500 units of anti-tetanic serum as early as possible, and to repeat this in the two following weeks. Should actual symptoms of tetanus arise, a dose of 10,000 to 20,000 units should be given, but the outlook is then extremely grave, as the curative value of the serum is far less than the prophylactic.

CHAPTER III

BURNS FROM HEAT (*continued*)

Local Treatment

General Considerations.—The local treatment of burns may be described most conveniently under the headings of burns of the different degrees, but before doing so there are certain general considerations which should be kept in view in order that the local treatment may lead to rapid and satisfactory healing, and of these the most important are the following :—

Burns have a greater tendency to become septic than almost any other form of injury to the cutaneous surface, as the devitalised tissue forms an especially suitable soil for the growth of septic micro-organisms. Every effort should be made to prevent and counteract this, and for this purpose aseptic rather than anti-septic methods should be employed. The use of strong antiseptics not only destroys the invading micro-organisms but injures the tissues themselves and is apt to delay healing; whereas the adoption of milder measures which induce a local hyperæmia and cause an increased leucocytosis encourages and

assists nature in combating the invaders and repairing the damage.

Another important point in the treatment of burns is to avoid as far as possible injuring the tissues and interfering with the new growth of epidermis over granulating surfaces by too frequent dressings. The less the wound is touched the better, provided the sero-purulent discharge is not excessive and no indications of septic absorption manifest themselves. Even when scabs and dressings are removed with the utmost care, the procedure is not only extremely painful but is almost certain to injure or bring away some of the newly formed delicate epidermal cells.

Until comparatively recently the favourite method of treating burns was by means of greasy applications, such as the time-honoured Carron oil or Linimentum calcis (equal parts of linseed oil and lime-water) and its substitutes. Lint saturated in this emulsion was laid on the burned surface, covered by a layer of cotton-wool and a piece of oiled silk, and fixed by a bandage. This type of dressing has such serious disadvantages that it has now been largely discarded ; the greasiness and the waterproof covering conserve the heat and increase the discomfort, and at the same time the Carron oil rather encourages than retards sepsis, so that under it a burn of the second degree, instead of healing quickly, may be transformed into the condition of one of the third degree and heal slowly with the formation of a subsequent scar.

Carbolic oil is another oily preparation which once enjoyed considerable popularity in this connection.

It has not the harmful effect of a powerful antiseptic, as the oil prevents the ionisation of the carbolic and interferes with its germicidal action, but it has the same disadvantages as other greasy preparations, and if employed over an extensive surface it is apt to be absorbed and may cause toxic symptoms.

Another fallacy with regard to the local treatment of burns is the old idea that in every form of burn it is of the first importance at once to exclude the air from the burned surface. This has been proved to be a complete mistake, and there is no better method, when practicable, for the healing of the raw granulating surfaces in burns of the third and fourth degrees than by exposing them to the air and encouraging the formation of a scab by powdering the surface with a bland aseptic powder. The exposure of the raw surface to the air at first may cause some smarting or even pain, but this quickly disappears as the serous exudation increases and bathes the delicate sensory nerve terminations.

Although the management and treatment of burns depend largely on the degree of the burn, there is little advantage in attempting to formulate any hard and fast scheme of treatment for each of the different degrees, as so much overlapping occurs that each case must be treated on its own merits.

The majority of burns which demand treatment belong to the second, third, and fourth degrees, those of the fifth and sixth degrees being comparatively rare, while those of the first degree are often so slight as scarcely to require any treatment.

The aims in the local treatment of burns may be thus briefly summarised :—(*a*) to prevent sepsis ; (*b*) to avoid giving pain to the patient by frequent dressings ; (*c*) to employ methods which favour the removal of the eschar and promote the re-growth of epidermis ; (*d*) to reduce cicatrisation to the minimum so that a soft pliant scar results ; (*e*) to prevent as far as possible contracture and deformity.

Burns of the First Degree.

In burns of the first degree, where the skin is simply scorched, the principal indication in the treatment is to relieve the burning sensation which accompanies the redness. This may be done by the continuous application of lead lotion (a teaspoonful of the Liquor plumbi subacetatis to half a pint of cold water) or by a 1 per cent. aqueous solution of acetate of aluminium. Pieces of lint should be soaked in one or other of these lotions, applied over the inflamed surface, covered by a layer of cotton-wool, and kept in place by a loose bandage.

Compresses of sodium bicarbonate solution (about a tablespoonful to a pint of water) may be substituted, but are less effective.

When the burning sensation has been relieved the compress should be removed and the skin dusted over with zinc oxide, talc, or some other bland powder. After being powdered it should again be covered with cotton-wool and bandaged so as to avoid friction.

If the forearm be severely scorched it may be an

advantage to keep the part immobile by a splint and a three-cornered bandage, and in the case of the leg to lie up for a day or two.

Where the erythema is intense great relief may be obtained from the application of pieces of lint soaked in a 2 to 5 per cent. aqueous solution of ichthyol.

When the redness has sufficiently subsided to render the cotton-wool and bandage unnecessary, calamine cream (prepared calamine 1 dr., zinc oxide 1 dr., almond oil 1 oz., lime-water 1 oz.) should be rubbed gently over the burned area, the superfluity wiped off, and dusting powder applied so as to leave the skin perfectly dry. This treatment is soothing and prevents minor degrees of friction.

Burns of the Second Degree.

In burns of the second degree the most important consideration in the treatment is the proper management of the vesicles and bullæ, and with regard to this there is some diversity of opinion. The serous contents of the blister, being in the first instance sterile, form a perfect dressing for the raw surface beneath, and on this account certain writers advocate the blister being allowed to shrivel and the contents to be absorbed without its being opened. As, however, the roof of the blister is usually delicate and apt to be broken by even slight friction, by the removal of dressings, or as a result of an increase in the exudation within the bleb, it is almost impossible to preserve it intact during the healing. When it is broken accidentally,

the serous discharge about the floor readily becomes septic, which may lead to superficial ulceration, and to avoid this it is better, on the whole, to open the blisters at the first opportunity with proper aseptic precautions.

Great care must be exercised in removing the clothes in burns of this degree, for should they be dragged off forcibly without previously being soaked in warm water or a weak solution of bicarbonate of soda the blisters will almost inevitably be torn open and the contents contaminated.

After removal of the clothes the surface of the bullæ and the skin in their immediate neighbourhood should be rendered aseptic by being mopped over with a solution of perchloride of mercury (1 in 4,000). Each bulla should then be opened aseptically in the dependent part, drained, and the cuticle left as a protective covering.

The burned area should now be dressed with gauze or lint soaked in 1 per cent. aqueous solution of aluminium acetate, which, being astringent and mildly antiseptic, is one of the best applications for burns of this degree. The gauze should be covered with a layer of sterilised cotton-wool, which should be retained in position by a bandage, or in the case of the face by a lint mask. The burned part should then be placed in a position of rest, in the case of the forearm and wrist by the use of a splint and sling and in the case of the foot and leg by keeping the limb in the horizontal position.

The dressings should be left alone as long as possible

and only taken off should any indication arise of the blistered area having become septic. Early sepsis in burns is easily recognised owing to the odour, which is unmistakable once it has been experienced. Should sepsis occur, the dressings should be removed with the utmost care and any wool or gauze adhering to the raw surface patiently soaked off with warm boric lotion—it should never be forcibly pulled away owing to the pain and the injury to the healing surface occasioned by such a rough procedure. Should pus have collected beneath the cuticle, it may be necessary to remove it so as to allow the purulent surface to be thoroughly cleaned; this should be done by gentle irrigation with warm boric lotion and on no account by strong antiseptics such as perchloride of mercury or carbolic. After cleansing the surface it should be powdered with equal parts of boric acid and zinc oxide, and the parts re-dressed with gauze soaked in aluminium acetate as in the first dressing.

Picric acid is another favourite dressing for burns of this severity. It can be used either in the form of a 1 per cent. aqueous solution or with the addition of absolute alcohol in the following proportions: picric acid ½ dr., absolute alcohol 1 oz., distilled water to 14 oz.

Picric acid has the great disadvantage of staining the skin yellow and if employed in burns of any extent, and more especially in those of the third and fourth degrees, it has been known to become absorbed and to give rise to symptoms of poisoning, such as vomiting,

diarrhœa, yellow vision, rise in temperature, dark-coloured urine, and even coma. This latter danger, however, has been greatly exaggerated and need not be feared unless the dressing be applied over a very large area.

Permanganate of potash solution, 1 in 4,000, is also sometimes used, but it has no advantages over aluminium acetate, stains the skin a brownish tint, and sometimes causes irritation.

Burns of the second degree have recently been treated with considerable success by the paraffin method, for a description of which see page 56.

Greasy applications, such as ointments containing eucalyptol, boric acid, ammoniated mercury, etc., are sometimes recommended, but they are heating, less effective, and much less pleasant to the patient.

In burns of this degree healing takes place rapidly, as the new epidermis grows, not only from the edges of the wound, but from epidermal remnants which have been left on the floor of the blister. Complete restoration takes place in about a fortnight, with little or no alteration in the texture of the skin, unless where the denuded surfaces have been allowed to become septic and superficial ulceration has occurred, when slight scarring may result.

Burns of the Third and Fourth Degrees.

Burns of the third and fourth degrees can be conveniently considered together, as in most cases overlapping occurs should the burn be extensive. In them a new element is added in the complete devitalisation

of the skin and possibly of the underlying subcutaneous tissue to form the eschar.

The treatment of burns of this severity may be divided into (1) the immediate treatment up to the separation of the eschar; (2) the healing of the granulating surface.

(1) **Treatment up to the Separation of the Eschar.**

As soon as the shock has been overcome, any charred clothes which may still remain after the patient has been put to bed should be soaked off and tags of epidermis or loose tissue removed. The burned parts should then be cleansed by irrigation with warm boric lotion, or by immersion in a bath containing boric lotion or warm saline solution. Occasionally the removal of the clothes may be so painful as to necessitate a general anæsthetic.

The burn should next be dressed with aluminium acetate or picric acid lotion in the same manner as burns of the second degree and the dressing retained by a loose bandage. If an ordinary roller bandage be too tightly applied in the case of a burned limb there is always a risk of causing gangrene, and to avoid this a useful dressing has been suggested by Staff-Surgeon Willan, R.N., consisting of antiseptic wool with gauze on either side which is stitched together in the manner shown in the diagrams, folded over the limb, and fixed by tapes.

The dressing should be changed as seldom as possible and should only be removed (1) if the burn become definitely septic, a misfortune which is unlikely to occur, as the astringent and slightly anti-

septic properties of the aluminium acetate or picric acid render the tissue an unsuitable soil for the growth of micro-organisms; (2) if it become painful, when relief may be obtained by immersing the burned part

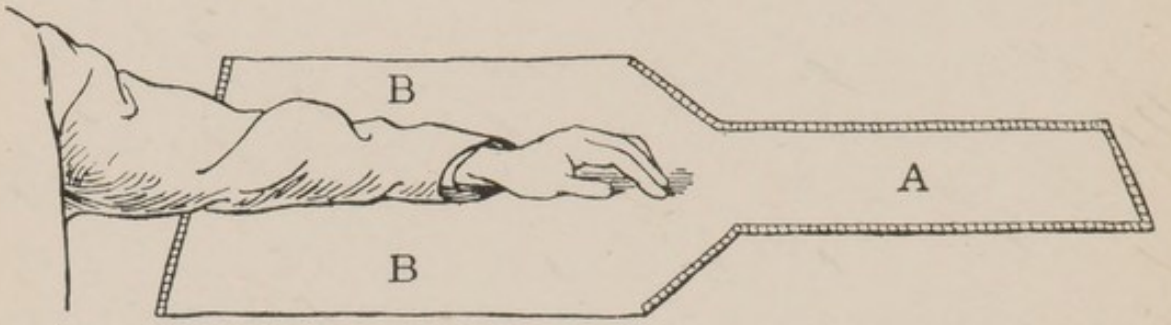


FIG. 5.—Willan's Dressing. Position 1.
Showing the dressing laid out ready for use with an arm *in situ*.

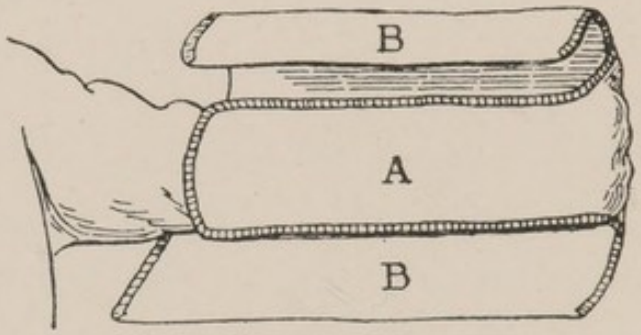


FIG. 6.—Willan's Dressing. Position 2.
The portion marked A has been turned back to cover the limb; the side portions, marked B B, overlap A and are secured in this position by tapes.

for several hours at a time in a bath containing warm saline solution.

In about fourteen days the eschar is probably ready to slough off and suppurative changes are occurring beneath and around it, so that about this time it is advisable occasionally to remove the dressing and to irrigate the sloughing surface with boric lotion.

(2) **Healing of the Granulating Surface.**

When the eschar has separated a superficial ulcerated surface is left which is usually uneven and covered with

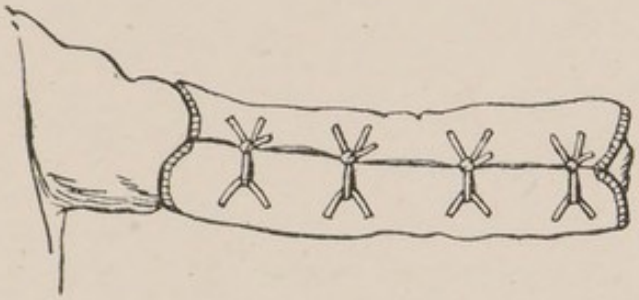


FIG. 7.– Willan's Dressing. Position 3.
Showing the dressing made secure.
(Note the distribution of the fastening tapes.)

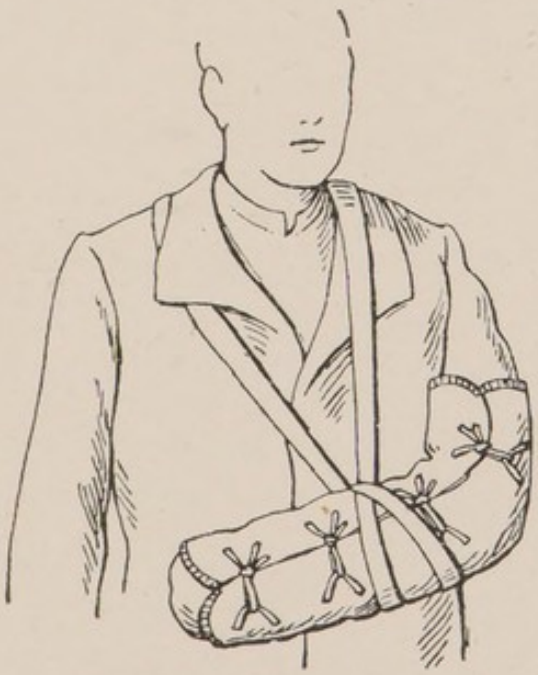


FIG. 8.—Willan's Dressing. Position 4.
The dressing complete.

moist, red granulations. Occasionally the separation may be associated with hæmorrhage; this generally takes place from the superficial veins and may require

treatment with the usual hæmostatics, such as nitrate of silver or perchloride of iron, and in rare instances from a larger vessel which it may be necessary to tie.

It is the successful healing of this granulating surface which forms one of the greatest difficulties in the treatment of burns and which so often taxes the patience of the doctor and the endurance of the patient.

The principal methods of treating the burn at this stage are the following : (*a*) open method, with healing under a natural scab ; (*b*) method of healing under an artificial scab, paraffin method ; (*c*) healing under moist dressings.

(*a*) **Open Method of Healing under a Natural Scab.**—Of all the methods at present employed for the healing of the granulating surface of a burn by far the simplest, and in some ways the best, is that which is known as the " open method " where healing is allowed to take place under a natural scab. In it no dressings are employed, but the raw surface is simply exposed to the air and powdered over with a bland aseptic powder which cakes up with the discharge to form a crust. It is particularly applicable to burns of the leg and face, though it can be used for burns of any part of the body.

Take, for example, the case of a burn of the leg in which the raw surface occupies the extensor aspect of the limb from the thigh to the foot. The procedure is as follows : a mackintosh sheet is placed under the leg and over it a long pad of cotton-wool covered by gauze on which the leg rests ; over the leg is placed a

cradle to keep off the bedclothes. In this condition the leg is left till healing has taken place. Should the patient complain of cold despite the blankets covering the cradle, an electric lamp may be suspended from the top of the cradle to raise the temperature. For this purpose one of the old 32 candle-power carbon

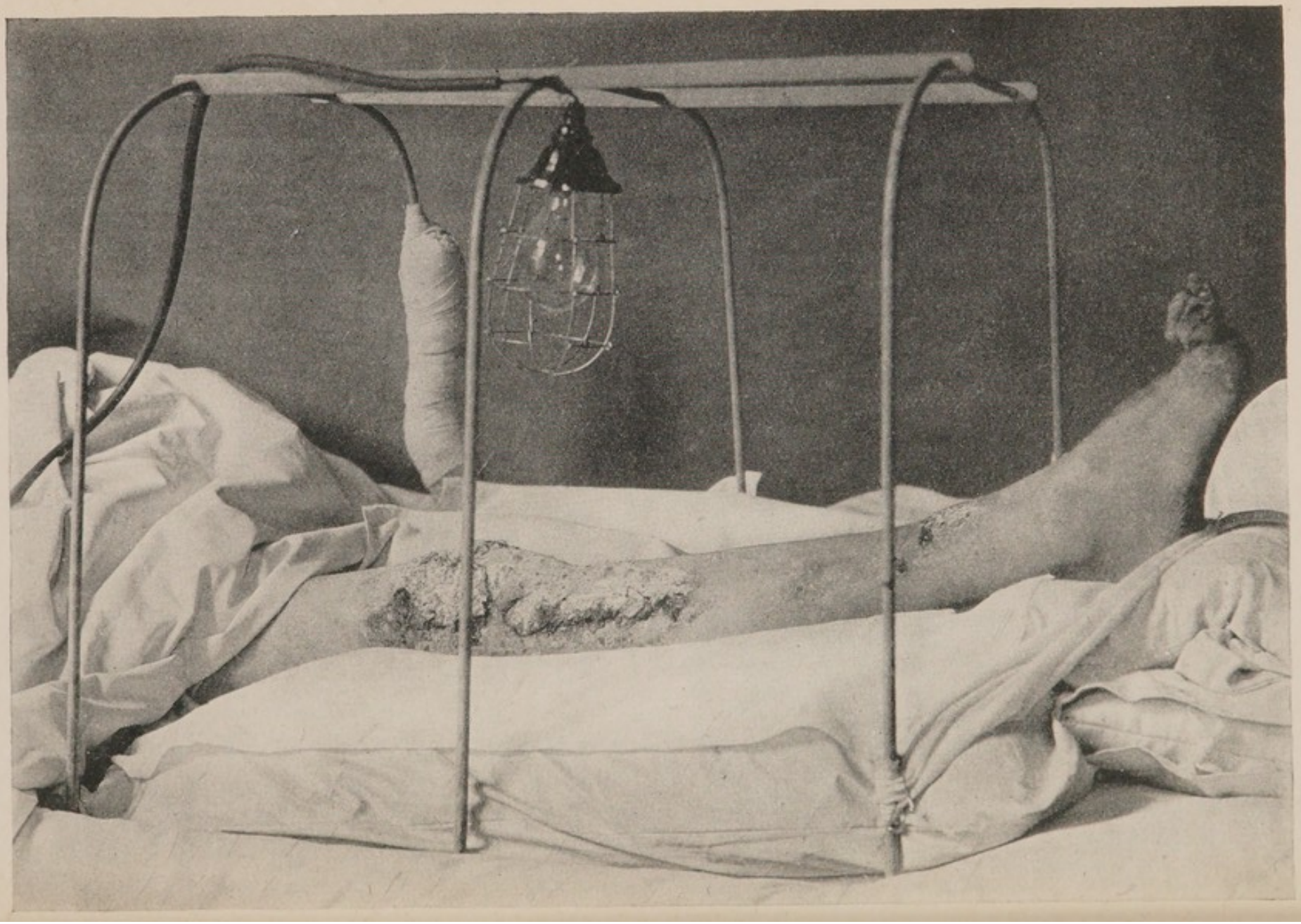
FIG. 9.—Open method of treatment. Burn of third degree of leg, healing under a crust of powder and discharge.

lamps is best and should be encased in a wire screen to prevent the blankets being scorched should they come in contact with it. By this means an even temperature of about 100° F. can be maintained.

Should the burn occur on the flexor aspect of the leg it is necessary to sling the limb from the cradle by gauze bands, so that it does not come in contact with the sides or with the bed beneath.

In the case of the arm some sort of protective wire cage should be devised to keep off the clothes and to prevent the scab being knocked off.

After the limb has been placed in position the granulating surface should be freely dredged over with powder. One of the most serviceable powders for this purpose is stearate of zinc, as it is non-



irritating ; before use it should be placed in a dredger and sterilised by heat to render it aseptic. Another useful powder is magnesium carbonate owing to its powerful desiccating properties.

A powder which the writer has found superior to either of these is a mixed powder containing stearate of zinc 20 per cent., carbonate of magnesium 40 per cent., Lycopodium 5 per cent., diamatos 25 per cent., paraffin 10 per cent., Ol. Citronell q.s. This powder, which was prepared for him by Messrs. John Bell and Croyden, is detergent, deodorant, and mildly disinfectant ; it has also the advantage of being slightly adhesive, and in consequence is most useful for burns on under-surfaces on which the powder cannot be dredged but has to be applied by means of an insufflator, such as that shown in the diagram.

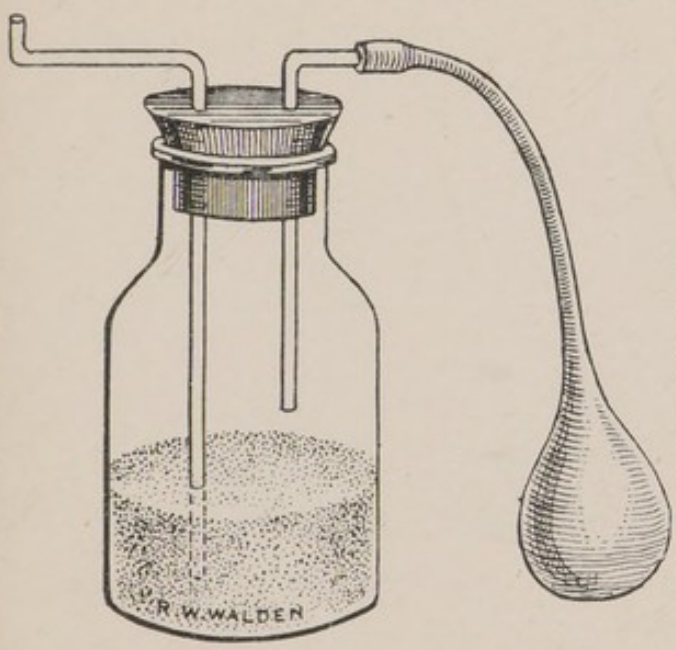


FIG. 11.—Insufflator for applying powder to burns.

At first the exposure to the air and the application of the powder may cause smarting, but this gradually disappears as a crust forms until the patient feels quite comfortable.

Powder is added from time to time, and the crust slowly increases in thickness till it becomes a coarse, uneven, yellowish-green scab ; in the case of

small burns it presents a limpet-like appearance, while where larger areas are involved it forms an irregular, crusted mass which may reach a quarter of an inch or more in thickness.

Here and there at the edge of the scab oozing of sero-pus usually takes place which trickles down on to the gauze. Should this discharge be excessive it may be necessary to remove a small portion of the crust, bathe away the sero-purulent fluid, and re-apply the powder. Once formed, the scab should be left

FIG. 12.—The same burn as in Fig. 9 in process of healing; two months later.

alone and touched as seldom as possible until it dries up, crumbles, and separates naturally. Should general septic symptoms supervene, however, or the discharge become excessive all round the scab, then it may be necessary to remove the crust completely and to clean the wound. This should be done carefully and any portions of the scab which are adherent should be softened with boric compresses before they are removed.

Where the surface is particularly septic an excellent method of dealing with it, when available,

is by exposure to ultra-violet rays. A short exposure of ten minutes to a quarter of an hour should be given at a distance of about six inches from an ultra-violet lamp. A useful lamp for this purpose is the Forbes lamp which has tungsten electrodes and gives a large output of ultra-violet rays. By this means the wound is cleaned up, assumes a more healthy appearance, and the crust may be allowed to re-form.

On no account should iodoform powder be employed to counteract the sepsis, as its unpleasant odour is objectionable to the patient and its irritating properties may not only be felt in the granulating surface but may set up a dermatitis in the neighbouring skin, while if used over an extensive area it is liable to be absorbed and to cause toxic symptoms.

A minor disadvantage of this treatment is that the odour of the scab and the sero-pus which may ooze out beneath it may be offensive to the patient, but this can be neutralised to some extent by placing a small vessel containing Condy's fluid within the cradle.

This method of treatment has several great advantages. It is ideal in that it allows nature to heal the part in her own way and avoids the injurious action of antiseptics; it leaves the wound, comparatively speaking, at rest and does not necessitate the terrible ordeal of periodical re-dressings with their pain and mental distress—the thought of which in some cases may become a veritable nightmare—and the interference with, or destruction of, the new growing epidermis each time the dressing is removed; at the

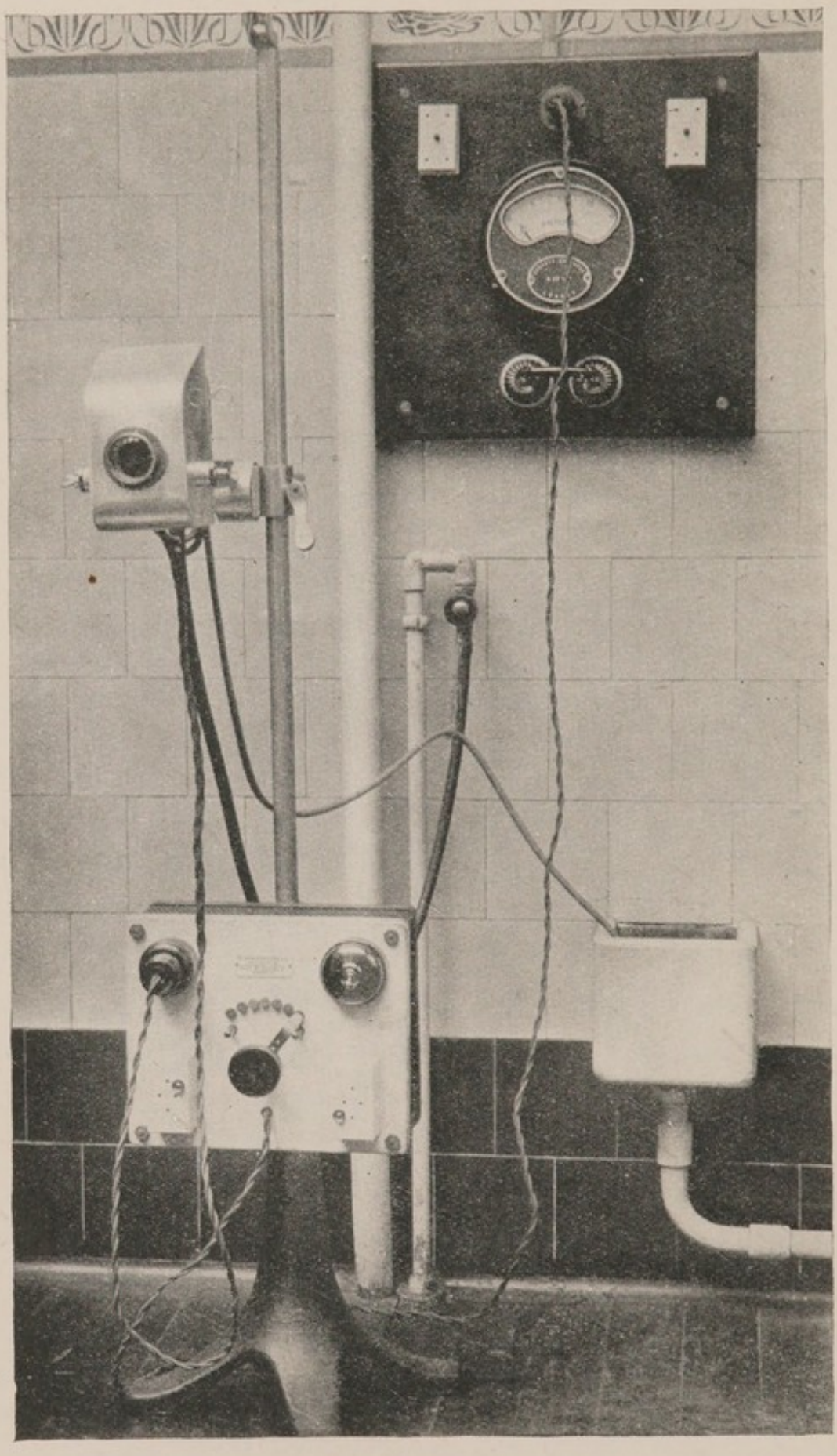


FIG. 13.—Ultra-violet lamp. (Forbes type.)

same time the pressure of the scab restrains, to some extent, the formation of exuberant granulations and avoids the necessity of grafting, which is so often unsatisfactory ; and when healing does take place a soft, pliant scar results which has comparatively little tendency to contract. A still further advantage is that the exudation covering the denuded surface beneath the scab before it has dried up bathes the delicate nerve-endings and soothes pain.

Though this treatment can be employed even before the eschar separates it is better, on the whole, to reserve it until all the dead tissue has sloughed away.

(*b*) **Method of Healing under an Artificial Scab.**—This mode of treating burns has been extensively employed during the present war in the form of the paraffin method and has been found to be of great value in burns caused by liquid fire, petrol, etc. It is by no means a new treatment as it has been in use in France for years.

Before describing the paraffin treatment reference may be made to the so-called Cargile Treatment, which is somewhat similar in principle and has several of its advantages.

Cargile Treatment.—According to the description by Sir Lambert H. Ormsby, cargile consists of sterilised strips of omentum of the ox. It is used as a dressing by being laid on the granulating surface, to which it applies itself closely, forming a sort of scab. This is covered by lint soaked in boric lotion, which is changed about once a day according to the amount of discharge which passes through the cargile,

which is so porous that it does not retain the secretions beneath it. When the burn is re-dressed only the lint is changed and the underlying cargile is left.

The following advantages are claimed for this treatment: that it soothes pain quickly; that the part of the dressing in contact with the wound does not require to be changed; that it prevents the entrance of micro-organisms without retaining the discharge.

Paraffin Treatment.—The treatment of burns by paraffin was introduced in France by Dr. Barthe de Sandfort, who employed a preparation known as ambrine.

Ambrine is a French proprietary preparation of paraffin wax, resin, and oleum succini. It is greyish-black in colour, solid when cold, and has a melting point of about 122° F. It is sterilised by heat and remains sterile on being re-melted at a lower temperature. When melted at a temperature of about 150° F. the hand can be borne in it and it can be applied to the skin without giving rise to pain. The preparation is melted and sprayed on the skin or painted on with a broad camel's-hair brush, and allowed to solidify to form a waxy scab or cast under which healing takes place.

One disadvantage of the ambrine dressings is the offensive smell which may be associated with them. This has been overcome by Lieut.-Colonel A. J. Hull, R.A.M.C., who recently introduced a paraffin preparation in which the smell is to some extent prevented by the addition of an antiseptic in the

form of resorcin or beta-naphthol. To this preparation, which has a melting point of 118° F., he gave the name of No. 7 paraffin.

No. 7 paraffin has the following formula :—

Resorcin	1·0	per cent.
or		
Beta-naphthol	0·25	,,
Eucalyptus	2·0	,,
Olive oil	5·0	,,
Paraffin molle	25·0	,,
Paraffin durum	67·75	,,

In preparing it, the hard paraffin is melted, the soft paraffin and the olive oil stirred in, and to this is added the resorcin dissolved in half its weight of absolute alcohol, and finally the eucalyptus oil when the wax has cooled down to a temperature of about 130° F.

Proprietary paraffin preparations of a somewhat similar constitution to No. 7 paraffin have now been placed on the market by various British firms.

The paraffin is sprayed on the burned area by means of a spraying apparatus, such as that made for the Navy by Messrs. Down Bros. This consists of a barrel, made of a solid brass tube, four inches in length and two inches in diameter, with a handle at one side and a short nozzle with a wide bore at the other. From the nozzle a capillary tube reaches to the bottom of the barrel while on the top of the lid, which screws on so as to make the chamber air-tight, is fitted an indiarubber spray bellows to provide the necessary air pressure to expel the paraffin.

The method of use is as follows : A piece of paraffin

wax is placed in the sprayer and melted over a spirit lamp or by setting the sprayer in a basin containing boiling water. The melted wax is then at a temperature of over 200° F. and must be allowed to stand until it cools down to about 150° F. before it is applied to the skin. Water must be prevented from getting into the sprayer as at a temperature of 150° F. it would cause scalding.

The burned area should be cleaned with boric

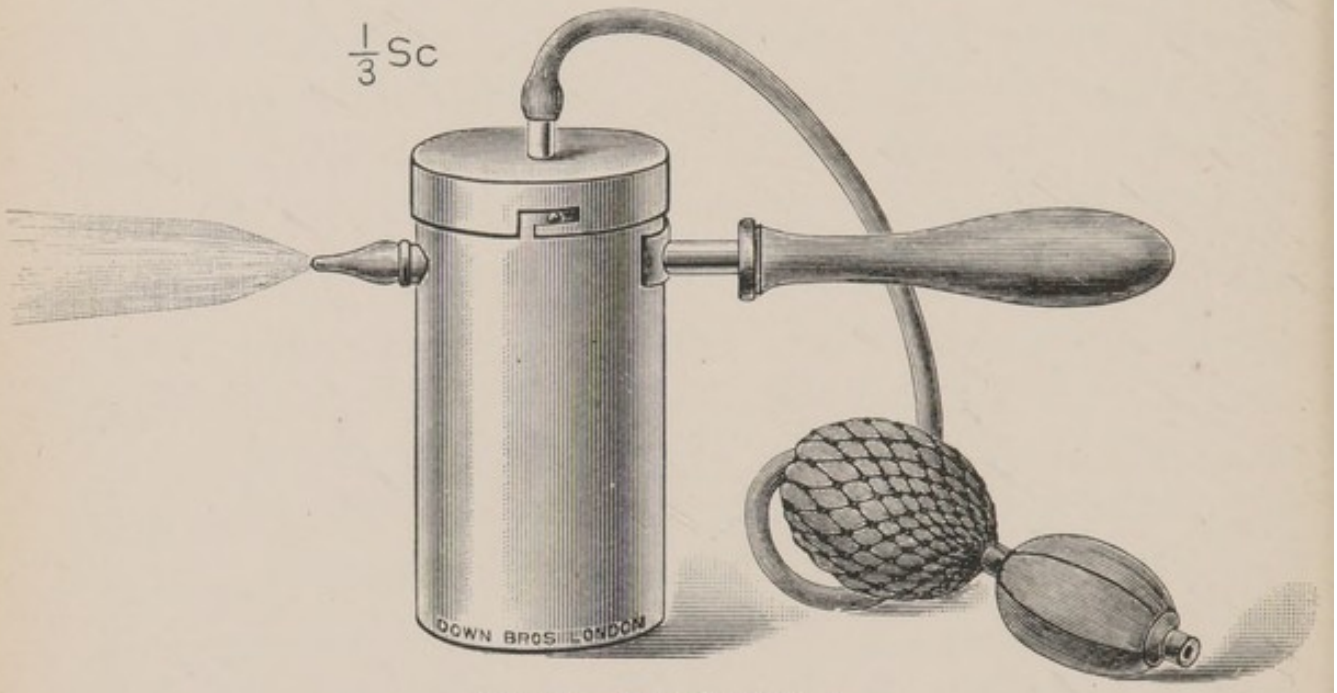


FIG. 14.—Paraffin Spray.

lotion, normal saline, or 1 in 1,000 acriflavine solution (Hull), carefully blotted dry, and the paraffin sprayed or painted on with a camel's-hair brush sterilised in the melted paraffin. When the sprayer is used it is held at first at a distance of about nine inches from the burned skin and the paraffin sprayed over the area, forming a thin coating which has been compared to hoar frost; the sprayer is then brought to a dis-

tance of about four inches from the skin, and the affected area completely covered with the paraffin. A thin layer of cotton-wool pressed flat between two layers of clean paper is next laid on the melted paraffin and dabbed over by the brush with more paraffin. When this cools a waxy shell or cast is formed over the burn. Should a thicker cast be desired a second layer of cotton-wool may be super-imposed and this in turn covered with paraffin. Over the cast is placed a layer of cotton-wool which is held in place by a loose bandage.

At first the burn is re-dressed every twenty-four hours, the waxy cast peeling off quite easily owing to the exudation which forms beneath it. The burned area should then be gently irrigated with weak boric lotion or normal saline solution, dried, a new cast of paraffin applied, and the dressing completed.

When the treatment is employed for burns of the second degree in which blebs are present the skin should be cleansed with boric lotion without breaking the bleb, dried, and the paraffin applied over the bleb. It should be re-dressed in about twenty-four hours, and then left on, if possible, for two or three days.

By this treatment healing takes place fairly rapidly with comparatively slight scarring and subsequent contraction, and it avoids, to a large extent, the necessity of grafting.

Should the healing be delayed and the granulations be flabby and unhealthy, Hull recommends the sub-

stitution of "scarlet-red paraffin," which contains 0·2 per cent. of scarlet-red, at the expense of the paraffin molle; this he claims to have greatly accelerated the healing.

The chief advantages of the paraffin treatment are: It alleviates pain; it protects the tissues and acts as a splint keeping them immobile; it prevents the underlying granulations becoming exuberant by the pressure it exerts; it interferes with the tendency for the discharge to become septic, by the heat of the paraffin killing off septic micro-organisms; and being non-adherent, it can be removed painlessly and without injuring the newly-formed epidermis.

(*c*) **Method of Moist Dressings.**—This treatment, though a great advance on that by oily applications, is inferior to both the natural scab method and the paraffin method. In it the granulating surface is covered by a layer of gauze, over which is placed a dressing of gauze or cotton-wool soaked in a mildly antiseptic lotion, such as boric lotion (a teaspoonful to a pint of water), and held in place by a loose bandage; this should be kept moist by soaking the dressing from time to time in the lotion without disturbing the gauze next the raw surface.

Instead of the boric lotion, Dakin's hypochlorite solution may be employed as used in the Carrel-Dakin method of treating wounds. This solution has considerable bactericidal property, is almost non-irritating, and practically harmless to the tissues. It contains a mixture of hypochlorite and polyborate of soda with small quantities of boric acid and free

hypochloric acid, and is nearly neutral in reaction. The granulating surface is kept continuously moist with the solution in the following manner: a small-bored rubber tube, perforated with small holes and connected with a vessel containing the solution, is placed on the raw surface and over it a dressing of gauze, and in this way both the gauze and the wound are kept soaked in the solution. Should the tube be placed above the gauze the latter is gradually impregnated with the secretions and soon becomes impermeable to the lotion. The vessel containing the solution should not be higher than an inch or two above the wound so as to reduce to a minimum the flow of lotion through the tube. Care must be taken that the lumen of the tube be kept free from blood-clots or from being kinked. It is, of course, necessary to arrange mackintoshes under the patient to prevent the bed becoming wet.

The following is the method of preparation of Dakin's solution by the Daufresne process:—

1. To prepare 10 litres of solution weigh out exactly:—

Chloride of lime (having 25 per cent. active chlorine)	184 grammes.
Carbonate of soda, anhydrous (carbonate de soude, Solvay, Fr.) ...	92 ,,
(Or carbonate of soda, crystals ...	262) ,,
Bicarbonate of soda	76 ,,

2. Place in a 12-litre flask the 200 grammes of chloride of lime and 5 litres of tap-water; shake vigorously two or three times, and leave all night.

3. Dissolve the carbonate and bicarbonate of soda in 5 litres of cold water.

4. Pour the solution of soda salts into the flask containing the suspended chloride of lime, shake well during one minute, and place aside at rest to allow the carbonate of lime to settle.

5. At the end of half an hour siphon off the clear liquid and filter it with a double paper to obtain a perfectly clear produce, which should be kept in the cold and away from the light.

The antiseptic solution is then ready for use. It should contain 0·475 per cent. of hypochlorite of soda, with small quantities of neutral salts of soda. It is isotonic to blood-serum.

(3) **Exuberant Granulations.**

Should the granulations become exuberant it may be necessary to astringe them, either by touching them with nitrate of silver or by applying a compress of aluminium acetate. A useful procedure consists in covering the affected area with a layer of oiled silk perforated with a number of small holes, placing over it strips of gauze soaked in aluminium acetate, and fixing by a fairly tight bandage, applied for half an hour at a time. In cases where the granulations are unusually excessive it may be advisable to curette them under an anæsthetic.

(4) **Grafting.**

Where the granulating surfaces resulting from a burn are large and the burn so deep that

no islands of epidermis are left, it may be advisable to resort to grafting in order to promote healing. This should be done as early as possible, even when the granulating surface is covered with sero-purulent discharge as this is no deterrent to the grafts holding. Fortunately, by the newer methods of treating burns under natural or artificial scabs the necessity of grafting is avoided to a large extent ; but even with them cases do occur in which the healing is so protracted that grafting may have to be resorted to, and this is especially the case in burns over joints where rapidity of healing is of the utmost importance to avoid an excessive formation of cicatricial tissue and serious contracture.

Thiersch grafting is the method usually employed, but is rarely quite satisfactory and as a rule only a small proportion of the grafts hold. The same may be said of the hair-grafting method, which consists in epilating a number of hairs, snipping off the succulent bulbous ends, and sowing them over the granulating surface on the off-chance of their holding and forming foci from which new epidermis may grow.

Another method of grafting, and one which has given considerable success, is that which was described by MacLennan as "tunnel" skin-grafting. In it a narrow strip of skin about half an inch wide and six inches long is excised from any convenient part, such as the thigh, the wound from it being sewn up and forming eventually a negligible linear scar. The graft is then cut up into thin longitudinal strips a quarter of an inch wide and three-quarters of an inch

long. By means of a pair of forceps a tunnel is made beneath the granulations, into which the graft is drawn and there left. Instead of the tunnel Lockhart Mummery has obtained good results by threading the grafts among the granulations with the help of a needle. So far as the holding of the graft is concerned, it is immaterial in what position the grafts lie, whether the epidermis be uppermost or not. In favourable cases a growth of epidermis takes place from about two-thirds of the linear grafts.

After the grafts have been applied, a layer of sterilised butter-muslin should be fixed over the grafted area—in the case of a limb the muslin can be put right round and the ends sewn together on the side opposite the burn—and any other dressing which may be employed to soak up the discharge, such as layers of gauze or sterilised lint, should be placed over it. When the part is re-dressed the butter-muslin should on no account be disturbed. By this means the grafts are protected and the discharge is enabled to escape through the porous muslin.

Another method of dressing grafted surfaces is a non-adherent dressing such as that suggested by Dale. This consists of gauze impregnated with an ointment containing ammoniated mercury 1 dr., white wax ½ oz., and zinc oxide ointment 1½ oz. The ointment is liquefied and sterilised by boiling, and strips of gauze are dipped in it and stored for use in sterile jars.

The grafted surface may also be allowed to heal under a natural scab, only being powdered over with stearate of zinc.

In some ways the most satisfactory method of grafting the granulating surfaces of burns is deep grafting by means of flaps cut down as far as the subcutaneous tissue, taken from the abdomen, buttocks, or whatever situation is convenient, and placed over the wound. At first the base of the flap is left uncut to enable the circulation to be maintained and about ten days should be allowed to elapse before it is separated. The chief disadvantage of this method is the unsightly scar which results in the situation from which the flap was taken.

Burns of the Fifth and Sixth Degrees.—In burns of these degrees amputation of completely charred parts, such as a hand, foot, finger, or toe, may be necessary, but otherwise the treatment is on similar lines to that described for burns of the third and fourth degrees.

When healing does take place in burns of the fifth degree serious contracture and deformity invariably result.

CHAPTER IV

BURNS FROM HEAT—(*continued*)

Regional Burns

The only situations in which burns and scalds require to be specially described are the eye, mouth, throat, and œsophagus.

Eye.—Burns and scalds of the eye may be caused by fire, steam, hot liquids, splashes from molten metals, and most frequently of all by corrosives (see page 124).

If the burn be slight no permanent injury may follow, but if severe it may result in opacities of the cornea, loss of vision, impairment of movement, and even destruction of the eyeball. The site of the burn may be indicated by a film on the conjunctiva, or, in deeper burns, by a greyish eschar which on separating leaves a granulating surface corresponding to that which occurs in burns of the skin. This heals in course of time by cicatrisation and the formation of a scar, which may go on contracting for months and lead to inversion of the lower eyelid and to a turning in of the eyelashes (Trichiasis). This is a

source of great trouble by irritating the conjunctiva, even to the extent of causing ulceration which, on healing, may be followed by opacities in the cornea and defective vision. It may also give rise to adhesions between the conjunctiva of the lid, especially the lower lid, and the eyeball (Symblepharon); this may restrict the movements of the eyeball or interfere with the closing of the lids, and result in the loss of protection of the eyeball so that foreign bodies are liable to lodge in the conjunctiva, where they may set up more or less acute inflammation and even ulceration, and may end in the destruction of the eyeball.

Treatment.—The first thing to do in a burn of the eye is to remove any foreign body, such as particles of the molten metal or grit, which may have lodged about the eyeball or the conjunctival sac. This should be done by wiping the eyeball with a piece of cotton-wool or by the use of forceps or a foreign-body spud. The conjunctival sac should then be freely irrigated with boric lotion and a cold boric compress applied. If there be much pain it may be soothed by the instillation of a 2 per cent. solution of cocaine or a 1 per cent. solution of holocaine hydrochloride, and if there be much congestion a few drops of a 1 in 10,000 solution of adrenaline will relieve it.

When the eschar separates it is of the utmost importance to prevent the formation of adhesions. This can be done to some extent by inserting an instrument, such as a probe, into the conjunctival sac and breaking down any adhesions which have

formed, and then washing out the eye with boric lotion.

In the event of entropion having taken place an operation for this deformity should be resorted to as soon as the cicatrix has ceased to contract.

Mouth and Throat.—Scalds of the mouth and throat most frequently occur in children from scalding liquids, a not infrequent cause being drinking out of the spout of a boiling kettle.

In adults they may be produced by the inhalation of steam in connection with some explosion, or by the accidental swallowing of too hot or boiling fluids.

The actual contact of the hot fluid with the mucous membrane causes it to become sore, red, and swollen, and possibly to be covered with whitish patches which present a peculiar shrivelled appearance. In scalds, even of a mild degree, the soreness may be so great as to prevent the patient swallowing food.

A more serious consequence than either the pain or the swelling may be œdema of the glottis. This may not occur immediately after the burn, but may develop some hours later, and is a danger which should always be foreseen and to deal with which suitable arrangements should be made beforehand. Where it is mild in degree relief may be obtained from scarification, but if severe it may necessitate intubation or tracheotomy to avoid suffocation.

When the danger of suffocation is passed there is still some risk of deeper trouble arising in the respiratory tract, such as broncho-pneumonia.

Scalds of the mouth are easily recognised and diagnosed from diseases in which membranes occur about the throat, such as diphtheria, as the membrane in burns is not confined to the tonsils and neighbourhood, but is present elsewhere about the buccal mucosa.

Œsophagus.—Should the burning fluid have passed into the œsophagus and caused a scald the mucous membrane may become swollen from œdema, and so painful as to prevent swallowing and to cause symptoms of shock; or it may become blistered and denuded, when it is liable to be followed by superficial ulceration which heals slowly and is apt to result in constriction of the gullet. The stenosis may increase for some months after the burn has healed, and is usually most marked near the upper orifice and towards the lower end.

Treatment.—In scalds of the mouth the patient is usually in such an extremely nervous and excitable state and is suffering so much from pain that a hypodermic injection of morphia may be advisable to quiet him down, while to counteract the signs of collapse it may be necessary to give an infusion of normal saline solution either per rectum or intravenously. For some time after the scald has taken place swallowing may be so painful that it may be necessary to administer food in the form of nutrient enemata.

After about a month, when healing has set in, in order to prevent constriction as far as possible, soft bougies should be gently insinuated into the œso-

phagus and this repeated as often as is deemed advisable. It may be an exceedingly painful procedure, and may necessitate a general anæsthetic.

Where serious constrictions have taken place and the gullet has become so narrow that swallowing of food is impossible, a gastrostomy may be necessary to enable the patient to be artificially fed.

CHAPTER V

BURNS FROM HEAT—(*continued*)

Prevention of Excessive Scar Formation, Contracture, and Deformity

The treatment of the unsightly deformities which result from the contraction of burn scars is so unsatisfactory that every effort should be made towards their prevention during the process of healing. Indeed, once contraction has occurred it may be not only difficult but practically impossible to remedy it.

With this object it is important to do everything possible to hasten healing by the adoption of one or other of the more modern methods of treatment, for the longer the granulating surface takes to heal the more hypertrophic or even keloidal the scar is liable to become and the greater the contraction which it may undergo subsequently.

It is essential that the limb be held in proper position during healing and for some time afterwards.

Burns on the extensor surfaces of the limbs are less liable to cause impairment of movement than burns on the flexor aspects, the flexor muscles being

apt to overcome the action of the extensors and to give rise to flexion deformities which may so restrict movement as to interfere with the utility of the limb.

During healing the leg should be kept in the extended position with the ankle at right angles to the foot. In burns of the axilla, the arm must be kept well abducted to avoid its being drawn against the body by the so-called "bat's-wing" deformity. In burns of the arm or hand, the elbow, wrist, or fingers should be extended. In burns of the front or sides of the neck, the head should be kept with the chin up.

It is necessary also to keep adjacent surfaces, like those of the fingers, toes, or eyelids, separated to avoid adhesions.

These positions should be maintained by the employment of suitable moulded poro-plastic splints, or of splints of plaster of Paris and gauze made specially to fit each case. These should be applied after the eschar has separated and worn continuously, an opening being cut in the splint the size of the granulating surface which should be allowed to heal under a natural scab or a paraffin dressing. The splints should also be made in such a way that they are easily removable when required, as it is advisable to take them off occasionally in order to move the joints passively and to massage the healthy tissues in the neighbourhood. They are not only of value in retaining the burned part in the proper position to avoid deformity but also, by keeping it immobile, they facilitate healing.

Plaster of Paris casts have been strongly recommended by Parker, of Chicago, whose method of dealing with burns is as follows: Strips of plaster an inch wide and long enough to reach the sound skin beyond the wound are placed over the granulating surface and made to overlap each other until the whole wound is covered. Over this, layers of gauze are placed to take up the secretion, the gauze being changed daily and the plaster twice a week—the plaster is easily removed as it does not adhere to the moist granulating surface. Over this again is made a plaster of Paris splint which is easily removable; in the case of the limbs the splint should be cut in two halves so that it can be taken off for re-dressing.

Should deformities have occurred, such as ectropion, fixture of limbs so that they cannot be extended, etc., plastic operations may become necessary, or the division of fibrous bands, or even the shortening of a limb by excising a portion of the bone.

Treatment of Scars from Burns.—When scars from burns are hypertrophic, unsightly, and situated on exposed parts such as the face, neck, and hands, various methods of treatment may be adopted to reduce the disfigurement, such as radium, X-rays, and fibrolysin. Of these, the most valuable are by radium and X-rays, and it is open to argument which is the better of the two. Whichever treatment be adopted it should be begun as early as possible, as the hypertrophy of the scar is usually most marked

immediately after healing has taken place, tends to diminish during the first six months, and then remains permanent, and it is during the first six months when the process of natural involution is occurring that most benefit may be derived from treatment.

Radium.—Half-strength plates of about 25 milligrammes of radium salt screened by a silver plate 0·5 mm. in thickness should be employed and exposures given of from ten to twenty hours divided over several days, according to the degree of hypertrophy. As the scar tissue reacts with difficulty to radium, it may be necessary to repeat the series of exposures. By this means a gradual absorption of the fibrous tissue takes place and a flattening out of the scar without any very marked reaction on the surface of the skin.

X-rays.—The X-rays are applied in pastille doses screened by a layer of thick felt, at intervals of not less than three weeks—great care being taken to protect the skin beyond the scar with lead. Several exposures may be necessary to produce any definite result, and the scar should be carefully watched in the process and the treatment stopped should any indication of dermatitis, however slight, supervene. The treatment is of especial value where itching is present in the scar, as this is usually allayed by the first exposure.

Fibrolysin.—Fibrolysin is a preparation of thiosinamine in which two molecules of that substance are combined with one molecule of salicylate of soda

and is in the form of a crystalline powder. It is employed in aqueous solutions of 15 per cent. strength, doses of 2 c.c. being injected into the scar at intervals of a week, or more often. This causes a mild inflammatory reaction which may be followed by slight softening and absorption of the fibrous tissue. Fibrolysin has been greatly advertised for the removal of scar tissue, but in the writer's experience the results from it have been disappointing.

Thiosinamine was the substance originally employed in this connection, and was injected in the form of a 10 per cent. solution in alcohol or in equal parts of glycerine and water. Though it has similar effects to fibrolysin, its use has been largely discontinued owing to the pain associated with its injection, and on this account fibrolysin was substituted as injections of it are painless.

Other methods of treating scars are by friction with a bland ointment and by massage, which may retard the growth to a slight extent and may relieve the itching.

Some benefit may also be obtained from exposing scars to ultra-violet light; this sets up an acute inflammatory reaction which may be followed by a partial absorption of the cicatricial tissue.

BURNS FROM HEAT

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CHAPTER VI

BURNS FROM ELECTRICITY

Injuries may be caused by electrical currents of high or low tension or by lightning. When due to electrical currents they are the result of contact with live wires, live rails, or live metal conductors in electrical power stations, etc., and are caused either directly by accidentally grasping or falling against the conductor, or indirectly through the medium of damp clothes, boots with nails, or some tool or instrument the handles of which were insufficiently insulated.

General Considerations.—The human skin when dry is relatively a non-conductor of electricity, and though not as perfect an insulator as indiarubber, still offers considerable opposition to the passage of electrical currents. Its power of resistance, however, is greatly diminished should it be wet, or macerated with soap, or moistened with a solution of some alkali such as common salt or bicarbonate of soda. It is the horny layer of the epidermis which is the most resistant part of the skin, the electrical current passing much more easily through the deeper layers of the

epidermis and the moist corium, and it is in situations such as the palms and soles where the horny layer is thickest that the resistance is at its maximum.

The degree of injury caused by the electricity—which varies from slight superficial burns to serious destruction of tissue, profound internal injuries, and even fatal shock—is commensurate with the quantity of current which passes through the body and the duration of the contact. The quantity of current is measured in amperes and is dependent on the voltage and the conductivity of the tissues through which it passes—the current being equal to the voltage divided by the resistance (Ohm's law).

Although the resistance varies in different parts of the skin according to the thickness of the horny layer and the dryness of the surface, for practical purposes the most important factor with regard to the actual damage to the tissues is the voltage or electro-motive force of the current.

Burns are produced both at the point of entrance of an electric current (anode) and at the point of exit (cathode), the injury at the point of entrance being greater, as a rule, than that at the exit. Currents of extremely low tension are capable of producing burns provided good contact is made with the skin. With a continuous current and metal electrodes insulated with chamois leather, moistened in salt solution, and placed against the skin, a sensation of burning and a muscular contraction is produced by a current of from 8 to 10 milliamperes, while should the insulation of the electrodes be imperfect

and the current allowed to pass for about a quarter of an hour, superficial burns of the skin will be produced at both the anode and the cathode. Consequently, in treating skin affections by ionisation, where prolonged contact is necessary it is of the first importance that the metal of the pole which completes the circuit should be sufficiently insulated. For example, in the ionisation of an ulcer with sulphate of zinc where the positive pole, consisting of a block of zinc, is placed on the ulcer with pieces of lint saturated in zinc sulphate interposed, and the negative pole in some convenient situation in the neighbourhood, if the negative pole be insufficiently insulated and a current of from 5 to 10 milliamperes passed for from ten to fifteen minutes, an intractable electrical burn will be caused corresponding in size to the metal of the electrode.

The degree of injury to the tissues increases directly with the amperage and, according to Lewis Jones, if the current reach 500 milliamperes (half an ampere) —to produce which requires a high voltage—not only will burns of great severity be produced, but a fatal result from shock may supervene.

The injury to the skin caused by an electrical current is probably greater when the skin is dry than when it is moist, for, when dry, it offers more resistance to the current and may be destroyed to a considerable extent in the process, while if moist it is a better conductor and the current passes more easily through it, is more rapidly diffused, and may do less superficial harm.

The concentration of the current is also an important factor with regard to the damage it may cause to the tissues, for the same strength of current when concentrated over a small area will result in injury of a more severe degree than when the current is diffused and the area of contact greater.

It is generally recognised that continuous currents are more liable to produce serious injuries than alternating currents; but, on the other hand, that alternating currents are much more dangerous in giving rise to fatal shock than continuous currents —according to the Board of Trade they are twice as dangerous.

Death from electrical shock is dependent on the voltage, and on the contact with the earth being good. Where the contact is good, currents of comparatively low tension may be fatal, whereas if the contact be less perfect currents of far higher voltage may be safely withstood. According to the return of H.M. Chief Inspector of Factories and Workshops in England and Wales in 1914, the lowest voltage which caused death in that year was 200, unless in a case where a shock from a voltage of 140 led to a fatal fall. Even lower figures are quoted by Jex-Blake, who states that fatal shock has been caused by an alternating current of 65 volts and by a continuous current of 95 volts. In America, an alternating current with a voltage of about 1,700 and an amperage of 7 to 8 is employed for the electrocution of criminals, but even with this voltage more than one shock may be necessary to paralyse the respiration, and cases

have been known in which a voltage of 2,000 and even higher was not fatal.

In 1914, out of a total of 449 electric accidents occurring in factories and workshops in this country 20 were fatal. With the increased employment of electrical power, with larger generating stations, with factories and other concerns driven by electricity, and with its more general use as a motive force for trams, trains, etc., the number of injuries and fatal accidents from it is likely to increase rather than to diminish, as the voltage employed for such purposes is far more than sufficient to cause a fatal shock. Even the ordinary electric light in certain districts in London is supplied by a continuous current of 240 volts ; the voltage in tube railways is about 500 ; that employed for arc lamps in the streets may be several thousand volts ; while the voltage in railways with an overhead system may reach 3,000.

Though injuries from electricity may be met with accidentally among the most expert and careful electricians, the majority would appear to occur among the more unskilled workmen and to depend largely on carelessness or ignorance, and many of them could be prevented with ordinary care. For instance, in touching any part of an electric light circuit, if the current has not been cut off care should be taken that, if possible, only one hand should be employed in handling the lamp, bracket, etc., while the other should be free and not touching any metal, and at the same time the individual should not be standing on metal or on a damp floor. On no account

should an electric lamp or telephone be placed too near a metal bath in case it should be touched by someone while bathing when in this way a current might be rapidly earthed and cause a dangerous shock. Instances of this sort need not be multiplied, so long as the importance of proper insulation is recognised and adequate precautions are taken by those who are liable to come in contact with live conductors of electricity.

Symptoms due to Electrical Currents.—The effects of electrical currents are both general and local.

General Effects.—The initial effect of an electric shock of any degree of severity is to produce unconsciousness, which, if not fatal, may last from 36 to 48 hours. At the same time, it gives rise to a powerful muscular contraction or tetanic spasm; this may force the individual to grasp the live wire or conductor and prevent his being able to let go, or it may cause him to be thrown violently several feet away from the contact, or force him to emit involuntarily a peculiar cry which is unmistakable to those in electrical works.

The patient is then found to be in a state of shock, with much the same symptoms as in concussion of the brain; the pulse is feeble and rapid, the temperature low, the extremities cold, the forehead and hands moist with perspiration, the face slightly cyanosed, the pupils dilated, and the breathing stertorous, while frothy mucus appears at the mouth.

Recovery from shock is usually followed by more

or less severe organic or functional changes in the peripheral and central nervous system, as the nerves are specially good conductors of electricity. These consist of paralysis—either permanent where it is the result of cerebral hæmorrhage or, more often, temporary though sometimes taking years before it disappears—and psychical disturbances such as hysteria, neurasthenia, delirium, delusions, insanity, or epileptic fits, which are usually transient but may persist for an indefinite period and may seriously interfere with the utility of the patient.

The special senses may also be implicated; the eyes may be affected and impairment of vision, flashing or dazzling sensations, or blindness from injury to the optic nerve, may occur; the ears may be involved and buzzing or actual deafness result; the sensation of touch may also be impaired. These effects are temporary unless where gross injuries to the nerves take place.

For some time after the shock the patient may complain of headache or vague pains in the limbs and elsewhere, which are usually aggravated should the atmosphere be charged with electricity, as in a thunderstorm.

Local Effects.—The injuries to the skin and underlying tissues from electricity are due, partly to the electrolytic action of the electrical current, and partly to the intense heat eliminated owing to the resistance of the skin to the passage of the current, in the same way as heat is given off in an ordinary electric lamp

where the resistance of the fine filament to the current is so great as to cause it to glow.

Burns from electricity are somewhat similar to those caused by heat, vary from simple erythema and blistering to deep destruction of tissue, and for descriptive purposes may also be classified into Dupuytren's six degrees. As a rule, they differ from heat burns, however, in that they have at first a peculiar, dry, charred appearance, have less tendency to become septic, are not so painful, and are far more intractable. According to the severity of the current, the charring may be confined to the skin or may reach down through the underlying tissues and may expose muscles, joints, or even bones.

Slight electrical burns are most liable to occur about the face and hands, as these parts are not covered by clothes, which, especially when dry, afford considerable protection.

In mild degrees of electrical burn the skin at the contact and in the neighbourhood not infrequently presents a cyanotic, œdematous appearance, and may be surmounted by tense or flaccid bullæ, the contents of which are occasionally hæmorrhagic. When the bullæ break the base is generally necrotic and tends to slough. In other cases, instead of forming bullæ, the skin separates in coarse, dry flakes. Sometimes the contact leads to a breaking up of fine particles of metal which become deposited and impregnate the skin for some distance around it, producing a brownish-grey pigmented appearance.

In burns of greater severity an eschar is formed

which is dark brownish or black in colour, of a hard, almost cartilaginous, consistence, and insensitive to touch. The skin around the eschar may be inflamed

FIG. 15.—Electrical burn of the second and third degrees, showing broken bullæ and charred skin.

and hypersensitive, but more often presents a peculiar white, bloodless, parchment-like appearance. The eschar may separate quickly, within twenty-four

hours, or it may not do so for a fortnight. There is not the same acute septic disturbance at its separation as there is in heat burns, and the process is more in the nature of a dry gangrene which, when it sloughs, leaves an unhealthy wound with a pungent or fœtid odour.

Where the burn has been severe and deep destruction of tissue has occurred, secondary hæmorrhage may take place when the eschar separates, partly from injury to the walls of the vessels and partly from degenerative changes in them.

For some time after the separation of the eschar, the necrotic process may continue and further sloughing may take place. This is due to the great devitalisation of the tissues which has resulted from the electrical discharge, and to some extent to the injury to the nerves supplying the part.

Although the gangrenous area may be considerable, it is usually so dry and necrotic that it is far more rarely associated with absorption of toxic products or septicæmia than are the sloughing sores from heat burns.

When the limbs have been the seat of severe electrical burns, they may be so completely devitalised as to become gangrenous, with the formation of a clear line of demarcation between the dead and the apparently healthy tissue.

Sometimes the injuries, instead of suggesting burns from heat, have more the appearance of wounds caused by some blunt instrument or weapon.

At the time of the contact the skin may not appear

to be affected, and it may not be for days afterwards that any definite lesion may appear on the cutaneous surface, but for some time after that new lesions may keep on developing. Nor is the amount of injury to the skin and underlying tissues any indication of the severity of the shock, for dangerous general symptoms, and often a fatal issue, may occur from an electrical current of low tension with comparatively little superficial evidence should the current have passed through a dangerous area such as the cardiac region. On the other hand, severe local injuries may sometimes be caused by electrical discharges without marked internal disturbance, as where the current has passed in and out of a limb instead of going through the trunk and meeting important internal organs on its passage.

Owing to the interference with the nerve supply, which may extend for a considerable distance from the actual injury, and the great devitalisation of the tissue, healing takes place extremely slowly in electrical burns, and may take two or three times as long as in the case of heat burns of a corresponding degree.

The resultant scar has a peculiarly delicate atrophic appearance, is puckered, pinkish or violet in one place, whitish or pigmented in another, and may here and there present a few telangiectases. It is so thin in places that it is easily abraded, and may break down to form an intractable superficial ulcer.

When the eyes are the site of the injury they may be seriously damaged by the electric sparks, the lids

become œdematous, the conjunctiva congested and painful, and, as a rule, there is marked photophobia. Later, opacities may develop in the cornea or the lens, retinitis may be produced, and even organic changes, causing blindness, may occur in the optic nerve.

The pain in connection with electrical burns is usually less than in heat burns, and may be entirely absent at first, and only become troublesome about the time that the eschar separates. It is due partly to electrolytic action, partly to heat, and to some extent to the tetanic spasm of the muscles. Its severity depends somewhat on the suddenness of the application of the current, as is seen in the employment of electrolysis for therapeutic purposes, where the sudden application of a current of medium strength may cause acute pain while a stronger current gradually applied may be quite bearable.

Pathological Considerations. Post-mortem Changes.—Of the various post-mortem changes which have been found in deaths from electric shock the following are the most constant: The right ventricle has been found to be filled with dark fluid blood, the lungs congested with hæmorrhages beneath the pleura, the liver and kidneys congested, the meninges congested with hæmorrhages in the brain, and Mott has detected chromolytic changes in the brain-cells.

Cause of Death.—There is some difference of opinion as to the exact manner in which death is brought about by an electric shock, and the question has been the subject of numerous experiments in

lower animals, such as dogs, rabbits, rats, etc., the chief point at issue being whether death is due to inhibition of the respiration or to primary cardiac failure.

According to D'Arsonval death is due to asphyxia. On the other hand, the experiments of Oliver and Bolam on anæsthetised dogs pointed rather to its having been caused by cardiac failure, the respiration continuing for some time after the heart had ceased beating. It has been suggested that the cardiac failure is produced by a contraction of the arteries putting too much strain on the heart, and in corroboration of this view Oliver found that stronger currents could be borne if nitrite of amyl were inhaled previous to the shock.

A distinction is drawn by Tousey with regard to the fatal effects of currents of low and high tension.

With currents of low tension, should the heart be in the direct path of the current, it is asserted that the immediate effect is to cause fibrillary tremors of the ventricles and heart failure, while the respiration, though it may be temporarily embarrassed by a tetanic muscular spasm, may continue for some time after the heart ceases.

High tension currents, on the other hand, are believed to be fatal not by causing cardiac failure but by inhibiting the respiratory centre in the Medulla oblongata, possibly as the result of hæmorrhage.

In support of this distinction, instances are on record where currents of very high voltage, such as

10,000 volts, have been survived; the explanation being that high currents well conducted do not have the same tendency to throw the heart into fibrillary contraction as weaker currents.

Death may also take place a few days or weeks after the accident from complications, such as gangrene, suppuration, exhaustion after extensive amputations, etc.

Diagnosis.—In electrical burns the history is usually so definite that the question of a differential diagnosis from burns due to heat does not arise.

If death be caused by electrical shock, it is the direct result of the electrical discharge inhibiting vital functions, either by stopping respiration or by fatally injuring the heart, while the collapse from heat burns may be of toxic origin.

Should shock be recovered from, there is distinctly less liability for death to supervene from toxæmia or septicæmia than in the case of heat burns, as there is less suppuration.

On the other hand, as sequelæ of electrical burns, in contradistinction to heat burns, more or less profound disturbances may be produced in the central and peripheral nervous systems leading to paralysis, and functional derangements of a psychical nature such as loss of mental balance, neurasthenia, hysteria, or epileptiform fits.

Prognosis.—Should shock be survived the prognosis, so far as a fatal issue is concerned, is good, and recovery generally takes place fairly

rapidly. With regard to the subsequent nervous derangements, these are generally temporary, though they may persist for a considerable period and may interfere with the patient moving about or being capable of any concentrated mental effort.

With regard to the burns themselves, they are extraordinarily intractable and heal exceedingly slowly.

Treatment.—In electrical accidents it not infrequently happens that the first thing which is necessary is to free the individual from contact with the live conductor—a procedure which is extremely dangerous until the current is broken and particularly so if the clothes be damp. If possible, the current should be switched off immediately, or in the case of a live wire the wire should be cut by long scissors with insulated handles or by an axe with a wooden shaft. If neither be possible and the individual has to be dragged away, whoever does it should protect his hands with thick rubber gloves, or, if these be not available, by wrapping them in folds of dry cloth, and should take care to avoid standing on metal or on wet ground.

After the patient has been removed from the contact, though he may seem to be lifeless, artificial respiration should be resorted to at once, as many cases have been saved in this way.

Either Shäfer's or Sylvester's method of artificial respiration should be employed; of the two the former is preferable, and should be continued until

definite evidences of death, such as cooling of the body or rigor mortis, have occurred.

The general treatment then resolves itself into the treatment of shock, by wrapping the patient up in warm clothes or placing him in a warmed bed and, if possible, giving a saline infusion either per rectum or intravenously.

Any nervous symptoms which may supervene subsequently must be dealt with on general medical principles.

The local treatment of electrical burns is similar to that described in connection with heat burns. Where possible, the "open method" should be adopted and the burns simply powdered over with stearate of zinc or magnesium carbonate (see page 51). When the eschar begins to separate every precaution should be taken against secondary hæmorrhage.

If the burn has been severe and penetrated deeply and a whole limb has been involved, the setting in of gangrene and the formation of a line of demarcation may render amputation necessary. In this case, even though the flaps are formed well above the line of demarcation, primary union need not be expected and sloughing may take place in the stump, not perhaps in the skin, but in the muscles as high up as their attachments. In consequence of this, Elder has recommended that the necrosed portion should be excised along the line of demarcation by a simple circular amputation and the stump left to granulate and subsequently skin-grafted.

Malingering.—Malingering in connection with electrical injuries is comparatively rare, though men have been known purposely to inflict electrical burns upon themselves by making contact with comparatively slight currents, with the object of avoiding work or obtaining compensation. Cases are also not infrequent in which claims have been made in connection with the Workmen's Compensation Act on account of various vague nervous disturbances which were said to have prevented the individual from going back to work. In such cases it is extremely difficult to estimate how much of the nervous injury is genuine and how much is feigned. In this connection it may be some help to find out, if possible, what the voltage of the current was which caused the injury and to what extent the claimant was insulated when the accident occurred, as in this way it may be possible to discover approximately the amount of current which he received and to come to some conclusion with regard to the probable degree of injury he is likely to have sustained from it.

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CHAPTER VII

Burns from Lightning

Lightning is a discharge of static electricity from a thundercloud to the earth, and when an individual is struck by lightning it means that he was in the path of this discharge.

Accidents from lightning, fatal or otherwise, are rare in this country in comparison with tropical countries, where thunderstorms and lightning are more frequent and severe. According to the Registrar-General's Report for 1914, the number of deaths from lightning in that year was only 31, and of these 24 occurred in males and 7 in females.

The effects of lightning, like those of other forms of electricity, are both general and local.

General Effects.—Death from lightning is directly due to the electrical discharge, which causes immediate unconsciousness and fatal collapse from cardiac failure, or from failure of respiration, the heart continuing to beat till stopped by asphyxia.

Where a fatal issue does not result from the lightning stroke, the individual, if not rendered completely unconscious, is usually in a semi-conscious or dazed

condition and exhibits other symptoms of shock, such as relaxation of the muscles, slow and stertorous breathing, a weak, rapid, and irregular pulse, and dilatation of the pupils.

Should the shock be survived, recovery is usually fairly rapid though temporary paralysis, neurasthenia, dazzling in the eyes or impaired vision, buzzing in the ears or deafness, headache, or some other more vague nervous derangement, may persist for an indefinite period; such symptoms being liable to recur or become aggravated during subsequent thunderstorms or when the atmosphere becomes surcharged with electricity.

Local Effects.—The local effects of lightning may be most severe on the exposed parts and less marked where the skin has been protected by clothes which, if dry, offer considerable resistance to the electrical discharge. If the clothes be dry, the lightning is apt to tear them to ribbons and may split open the boots or rip the soles from them. If the clothes be damp and the person struck be sitting or lying on wet ground the current may be rapidly diffused and so quickly earthed that the actual injury to the body may be less severe than where the clothes and skin were dry. This is not invariably so, and cases have occurred in which an individual with wet clothes has been struck and the clothes have been blown to pieces, possibly from steam, and death has resulted.

Occasionally shock, temporary paralysis, or even death, may occur from a lightning stroke and when the body is examined practically no trace of injury or

destruction of the clothes be noticeable, and even the post-mortem examination may give negative results.

The lightning causes destructive changes in the skin both at the entrance and exit of the current, and may give rise to serious injuries leading to hæmorrhages in internal organs which have been in the direct path of the current.

There are three different types of local lesion which may be caused by lightning, namely :—

(1) Wounds or contusions which resemble injuries from a blunt weapon or a heavy stick and are sometimes so severe as to lead, not only to injury of the skin and subcutaneous tissue, but even to fracture of bones.

(2) Burns of the skin like electrical burns caused by, and sometimes of the same shape as, metallic objects worn by the individual, which have acted as conductors, such as keys, coins, a watch, a metal matchbox, metal buttons, hatpins, etc.

(3) Arborescent markings, linear streaks, etc.

Of the three, the most peculiar and characteristic are the arborescent markings. These are radiating red streaks which spread for some distance over the cutaneous surface from the sites of entrance and exit of the current and break up somewhat like the branches of a tree. They are usually simply red, inflamed streaks, or occasionally linear wheals, but in rare instances they may be purpuric or even necrotic and on becoming involuted are not infrequently replaced by an arborescent pigmentation. They have attracted considerable attention, and various

hypotheses have been advanced to explain them. An old and obsolete theory is that they are due to actual particles of some tree and its branches, near which the individual was standing when struck, being pulverised and impregnating the skin. They are now generally believed to be formed in the track of the discharge of the static electricity, which has been split up in a dendriform fashion, possibly through differences in the conductivity of the tissues. Should the burn occur in a hairy region the hairs are usually singed.

Treatment.—The treatment of injuries from lightning is similar to that of other forms of injury from electricity. If the stroke has been severe and the patient be unconscious, the clothes should be loosened, artificial respiration at once resorted to, and the shock treated by warm saline infusion, hot drinks, etc. The local injuries should be dealt with subsequently according to their severity in much the same manner as burns from heat.

Protection against Lightning.—In a thunderstorm it is obviously safer to be indoors than out. The windows and the door of the room should be kept shut, and it is advisable not to sit in a draught and to keep away from the walls or the fireplace as, should a chimney be struck, the fireplace may be blown into the room and cause considerable damage.

If compelled to be in the open it is safer to sit or lie down than to stand up and, where possible, it is well to keep away from crowds of people or herds of animals.

If on horseback or in some vehicle, it is safest to dismount and to sit down clear of the tethered horse or of the vehicle.

It is important to keep away from isolated trees, pools of water, wet hedges, wire fences, etc. ; of these the most dangerous is a wire fence, as the lightning may strike the fence at a considerable distance from where a person may be standing and yet reach him by running along the wire.

It is much safer to go into a wood than to stand by an isolated tree, but in any case it is wise to stand as far as possible from the tree trunk. The conductivity of trees to electricity varies greatly ; the best conductor, and therefore the most dangerous tree to be near, is the oak, while the safest and the one which is most seldom struck is the beech.

For references, see page 95.

CHAPTER VIII

A.—BURNS FROM X-RAYS

Introduction.—Burns from X-rays are due to an over-exposure to the rays, either from one or more excessive doses or from the cumulative action of a series of smaller doses each in itself harmless. The over-exposure may be the result of the irradiation being too powerful or too prolonged, or it may be caused by the X-ray tube being too near the skin, for the effect of the X-rays varies inversely with the square of the distance of the tube from the cutaneous surface. Individual susceptibility may also be a factor in the production of an X-ray burn, but is one of minor importance.

Burns from X-rays are peculiar in that they do not appear at the time of the exposure but after a latent period which varies inversely with the severity of the burn. Nor is the X-ray exposure associated with any immediate subjective or general symptoms such as accompany burns from heat, though later, when the burns appear, the pain may be very great and general symptoms may arise from it or from septic complications.

A few hours after an exposure to a massive dose of

X-rays where the tube has been too near the skin, a patch of erythema may appear which may be associated with slight œdema. This is a transient condition which is not due to the X-rays but to electrical discharges around the tube and, possibly, to heat.

Symptoms.—There are two types of X-ray burns, namely, (*a*) acute X-ray burns which result from one or more excessive doses, and (*b*) chronic X-ray burns caused by small doses frequently repeated over a long period.

(*a*) **Acute X-ray Burns.**—Burns caused by an over-exposure to the X-rays vary in severity according to the strength and duration of the exposure. The dose of X-rays which the healthy skin is capable of standing without harmful effects—other than a falling out of the hair, which is temporary—can be estimated conveniently by means of the Sabouraud pastille, which is now largely employed as the standard of dosage in X-ray therapeutics. Any greater dose may be regarded as excessive, and is almost certain to be followed by a more or less severe burn.

For purposes of description acute X-ray burns may be classified into four degrees :—

Burns of the first degree are characterised by erythema and sensations of itching or burning. They appear about the fourteenth day after the exposure, and pass off in a few days, either leaving no trace or being followed by slight desquamation. They are accompanied by a falling out of the hair in the exposed area, but it usually grows again, though

sometimes imperfectly. This degree of burn may result from a pastille dose where a particularly sensitive area of skin was exposed or in an individual with an undue susceptibility to the rays.

In *burns of the second degree* the erythema is of a deeper tint, the skin is raised and œdematous, and the itching more severe. They come on about the eighth day after the exposure, take three or four weeks to disappear, and are followed by desquamation, slight atrophy, permanent loss of the hair, and some months later by the appearance of telangiectases in the atrophic area.

Burns of the third degree are of a much more acute type and manifest themselves before the end of the first week. In them the injured skin becomes markedly œdematous, or vesicles or bullæ may develop upon it. When these break a raw, painful, ulcerated surface is left which may be covered with a superficial slough. This heals slowly, sometimes taking many months to do so, and the resultant scar is shiny, hairless, atrophic, dotted over with telangiectases, and readily breaks down to form small, irregular ulcers.

Burns of the fourth degree appear as early as the second day and are so severe that sloughing may take place for half an inch or more in depth and in situations such as the scalp may reach down to the periosteum or the bone. A deep and intractable ulcer results, with a red, irregular border sometimes soft and flabby, at other times definitely indurated, with unhealthy granulations at the base covered with an adherent, greenish-yellow, fibrinous slough.

The ulcer is accompanied by pain, which may be continuous and is sometimes of the most agonising and stabbing type, like that which occurs in bone disease; this interferes with sleep and gradually undermines the strength of the patient who may be already considerably weakened by septic absorption from the indolent ulcer.

(*b*) **Chronic X-ray Burns, or Dermatitis.**—This type of injury is most frequently met with in X-ray operators or tube makers, and especially in those who began to expose their skin to the rays before the dangers connected with them were recognised. As a rule, it is the backs of the hands and fingers which are most affected, though occasionally the face may be involved from getting too near the tubes in testing them.

The first indication of the dermatitis may be a brownish pigmentation of the skin, diffuse or patchy, which is the result of the initial stimulating action of the rays; or it may consist of an atrophy, the skin becoming dry, smooth, and shiny, from a stretching-out of the natural fissures and a loss of the lanugo hairs.

Another peculiar and characteristic feature of chronic X-ray burns is the presence in the atrophied skin of telangiectases and hæmorrhagic puncta. The telangiectases are coarse and irregularly dotted over the atrophic areas, or fine and aggregated together in reddish patches. The hæmorrhagic puncta are due to the rupture of the dilated capillaries and are sometimes intensely painful.

Associated with the objective changes in the skin there is more or less marked itching or burning, which

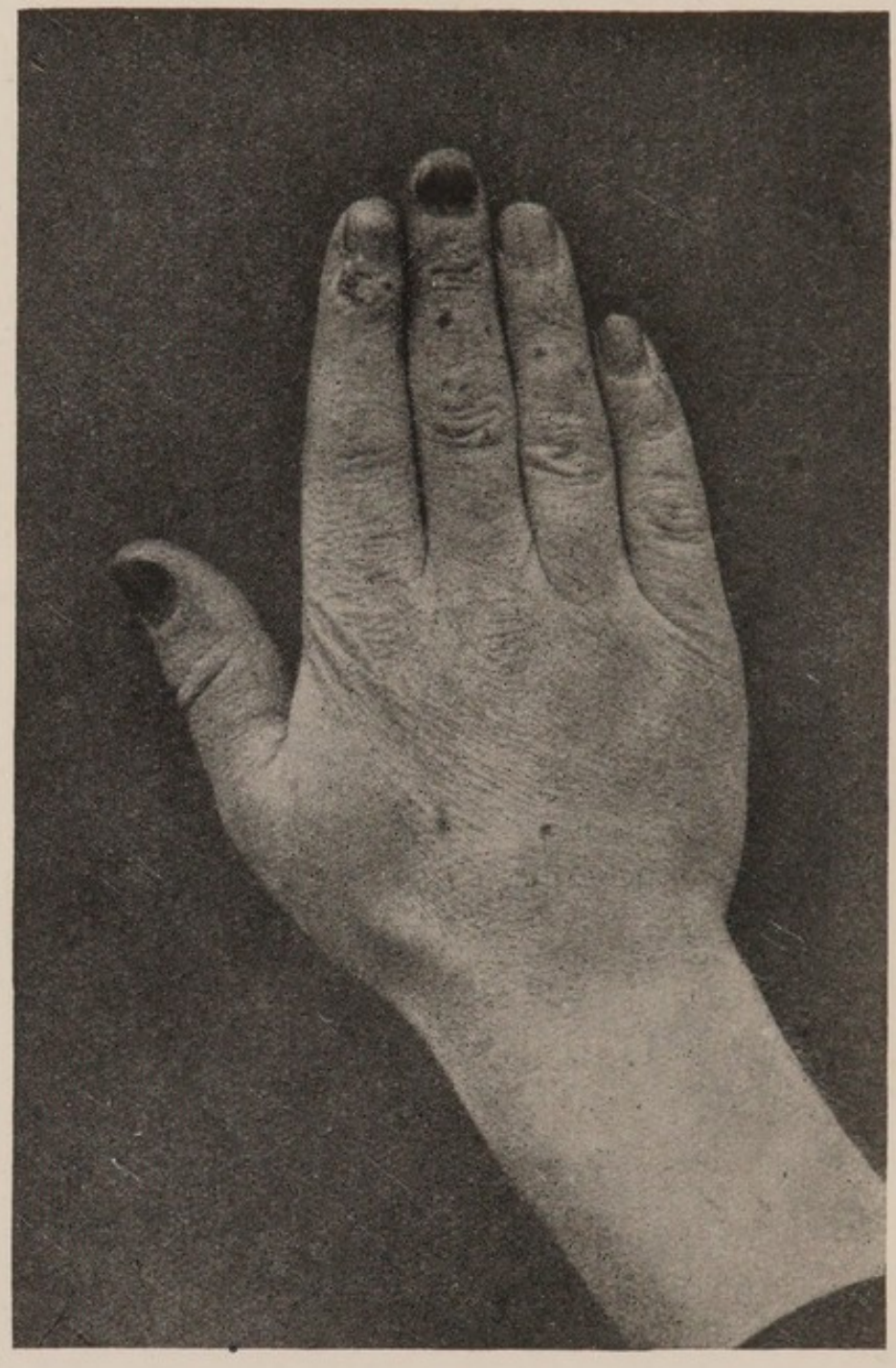

FIG. 16.—Chronic X-ray burn, showing superficial ulcerations, small warty growths, and changes in the nails.

is generally intermittent in character and is usually worse in cold weather. The affected skin also becomes peculiarly sensitive to the X-rays so that even

being present in the same room with an unprotected live tube may be distinctly felt.

In advanced cases, to the atrophy and telangiectases are added superficial horny growths, which are of a greyish or blackish colour and impart to the skin a

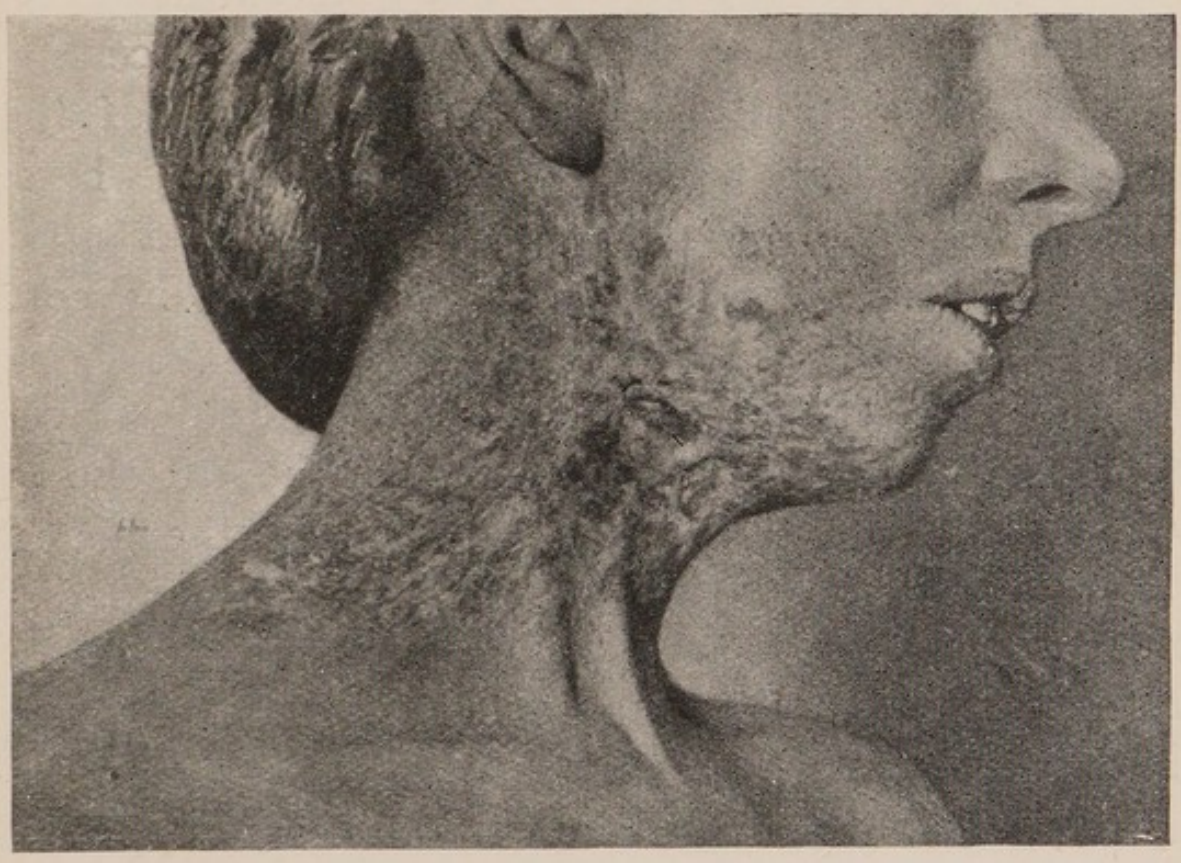

FIG. 17.—Chronic X-ray burn, showing atrophic skin, superficial ulceration, and telangiectases.

dirty appearance. These are a great source of trouble, as they are liable to be broken off, leaving superficial ulcers, or they may become inflamed at the base, grow rapidly, and develop into carcinomata. When malignant changes supervene in these horny growths or ulcers they are generally of a serious nature and associated with metastatic growths in neighbouring glands, and may lead to a fatal issue.

Owing to the diminished resistance of the skin, even slight abrasions are apt to result in the formation of intractable ulcers, which are irregular in outline, are often surrounded by a red inflamed border, and present an unhealthy-looking base covered by an adherent greyish membrane or a semi-purulent discharge. A common situation for these ulcers is over the joints, especially over the knuckle of the middle finger, but they may occur anywhere. They heal with the utmost difficulty and after healing tend to break down, especially in cold weather.

In severe cases, not only the skin but the subcutaneous tissue may become atrophied, the fat being replaced by fibrous tissue; while even the bones, especially spongy bones, may become soft and disappear, leading to shrinkage and deformity. In rare instances actual gangrene of fingers has been known to occur.

The nails are affected in nearly all cases of chronic X-ray burns of the hands, and become opaque, brittle, ridged, and frayed, or chronic suppurative changes may supervene about the nail-bed and nail-walls which are markedly painful and liable to end in separation and shedding of the nail.

Pathological Considerations.—The precise action of the X-rays on the tissues is not fully understood. At one time it was believed that the rays acted mainly on the nerves and that the changes in the epidermis and blood-vessels were induced secondarily. This

view is no longer held, and the prevalent hypothesis at present is that the rays act directly on the cellular elements exposed to them, causing changes which develop slowly and are of a definite character, and that they act most powerfully on weakly resistant cells, such as are met with in certain new growths of the skin, for example, in warts, rodent ulcers, etc. The changes are essentially of a degenerative type and the cells become devitalised, shrivel, and disintegrate. As a result of their disintegration, toxic substances are produced, setting up the inflammatory reaction which occurs from ten to fourteen days after the exposure. Should the dose have been excessive the inflammatory reaction is intensified and appears earlier. It is this reaction and its consequences which constitute the X-ray burn.

When the process of repair sets in and healing takes place permanent changes are found in the blood capillaries, which may be dilated or cavernous or may be obliterated by new fibrous tissue.

Prognosis.—In X-ray burns of a mild degree resulting from a single over-dose, the prognosis is good and complete recovery of the skin may be expected. Where vesicles or bullæ have formed, a telangiectatic scar and permanent loss of hair in the exposed area are apt to supervene.

More severe burns may result in the most serious sequelæ, such as sloughs, gangrene, or extremely painful ulcerations which eventually become malignant.

In chronic X-ray burns, if telangiectases only are

present the affection may gradually improve under suitable protective treatment.

Should ulceration and horny growths have developed the outlook is more serious and the prognosis should be guarded, as the ulcers may take months or years to heal and are liable to break down subsequently, while the horny growths have a marked tendency to become carcinomatous.

Treatment. Acute X-ray Burn.—In X-ray burns when the skin is simply inflamed and œdematous, the treatment should be soothing and astringent and the skin protected to prevent friction. Compresses of lead lotion should be applied and the skin dusted between times with boro-zinc dusting powder, and covered with cotton-wool fixed by a bandage.

When bullæ have formed they should be bathed with a weak solution of perchloride of mercury, opened in the dependent part, drained, and a dressing of aluminium acetate lotion applied.

Ulcers should be cleaned by astringent antiseptic lotions, such as zinc sulphate solution, black wash, or hydrogen peroxide 5 vols., and dressed with a soothing ointment, such as salicylic acid 10 grains, menthol 5 grains, vaseline 1 oz. Should the pain be excessive and the ointment unsuccessful in relieving it, excision of the ulcer may be resorted to where practicable. Where excision is impossible, the pain may be relieved by cutting the nerves which supply the ulcer, by making a deep incision above it and allowing the wound to granulate. In some cases healing may be obtained by the aid of Thiersch grafting.

Where there is any suspicion of malignant development, excision, or even amputation, may be advisable, but the latter should only be done where a part, such as a finger, has become gangrenous and a line of demarcation has formed.

Chronic X-ray Burns.—The treatment of chronic X-ray burns is tedious and disappointing. Slight cases, in which only telangiectases are present, gradually improve and may eventually cease to give trouble, but when horny growths and ulcerations have appeared the condition is extraordinarily resistant to treatment, prone to relapse, and apt to be gradually progressive.

The first essential in the management of these cases is to protect the skin from external irritation. It should be washed as little as possible with soap and water and any dirt should be removed by cold cream ; gloves should be worn as a protection from cold and from the actinic rays of the sun, and for this purpose brown cotton gloves are particularly useful. X-ray operators, if they are unable to give up working with live tubes, should be carefully protected from the rays by suitable gloves, opaque tube shields, a lead glass panel behind the fluorescent screen, and by standing as far as possible behind the anti-cathode.

The skin should be kept astringed and pliant by the application of the following ointment :—

Ichthyol	10 gr.
Zinc oxide	1 dr.
Cold cream ad.	1 oz.

while burning pain or itching may be relieved by compresses of lead lotion.

The removal of the telangiectases is unsatisfactory and attempts to destroy them by means of electrolysis or a fine-pointed cautery are disappointing. Where they are closely aggregated in small reddish patches, improvement may be obtained by short exposures to a radium plate suitably screened.

Warty growths, if present, generally demand treatment. In situations where the skin is slack, such as the back of the hand, the best method of dealing with them is by excision. Good results may also be obtained by shaving off the top of the wart with a razor and applying radium to heal the base and to destroy any of the growth which may remain. It is unwise to attempt to get rid of them by the actual cautery or by refrigeration with solid carbon dioxide, as this is liable to result in intractable ulceration and may possibly lead to malignant growth.

BURNS FROM X-RAYS

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B.—BURNS FROM RADIUM

Introduction.—Of the various radio-active substances the only one which is sufficiently concentrated, and the radiations from which are sufficiently powerful, to cause burns is radium, and from it burns may be produced which closely resemble those due to the X-rays.

The rays which are given off by radium are known respectively as the Alpha, Beta, and Gamma rays, and of these it is the Alpha and soft Beta rays which are responsible for a burn and not the more penetrating hard Beta and Gamma rays. As in the case of the X-rays, there is a latent period between the exposure to the radium and the appearance of the burn, and this varies inversely with the intensity of the irradiation. In the case of powerful exposures, the burn may appear in three or four days, while after weaker exposures it may not develop for ten or fourteen days. The degree of the burn, or reaction to the radium, is dependent on the strength of the applicator, the area of its radio-active surface, the thickness of the filters employed, the duration of the exposure, and to a minor extent on the susceptibility of the patient.

Symptoms.—In its mildest form, in which it almost

invariably occurs, a radium burn is characterised by transient erythema with itching and burning; if more severe it may be associated with œdema, bullous formation, and superficial ulceration; while in its most severe form it may give rise to deep ulceration with purulent sloughing.

The scar which results from radium burns even of a medium degree is generally depressed, hairless, pigmented, covered with telangiectases which may not appear for six months or more after the exposure, and peculiarly sensitive to heat and cold. Like the X-rays, radium is capable of stimulating the formation of pigment in the skin, and this may be observed even after slight exposures.

The burn is the evidence of an inflammatory reaction occurring in a tissue the vitality of which has been reduced by the rays from the radium, and which is set up in all probability by the toxic products of devitalised cells.

Prognosis.—The prognosis in burns from radium is generally good, as the burns are usually of a mild degree and the erythema disappears in course of time without leaving a trace. In more severe burns the outlook is less favourable, as they heal slowly and are liable to be followed by atrophic telangiectatic scars.

Treatment.—The treatment of radium burns consists of soothing the erythema with lead lotion or astringent dusting powders, dealing with the bullæ in the same way as in X-ray burns—by opening them aseptically and dressing the part with aluminium

acetate lotion—and treating the ulcerations by soothing antiseptic ointments.

Little can be done to remove the telangiectases by electrolysis, but slight improvement has been obtained by the deep application of the penetrating Gamma rays by long exposures to radium heavily screened—a procedure which is believed to cause a constriction of the capillaries by stimulating the formation of new fibrous tissue.

BURNS FROM RADIUM

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CHAPTER IX

BURNS FROM THE SUN

Introduction.—The specific effects of sunlight on the skin are due to the actinic or chemical rays of the violet end of the solar spectrum, and consist of pigmentation in the form of sunburn and freckles, or dermatitis, varying in degree from acute burns due to an excessive exposure to sunlight in a sensitive skin to chronic solar dermatitis from repeated exposures in a skin which reacts less readily to the harmful effects of the rays.

Burns from sunlight are comparable to those caused by X-rays, but are more superficial and have a shorter latent period between the exposure and the reaction.

The effects of the sun's rays, both clinical and histological, have been carefully studied in recent years since the introduction by Finsen of actino-therapy in the treatment of skin diseases. Long before Finsen's time, however, it was known that it was the blue and violet rays of the spectrum which were harmful to the skin, and not the red and yellow rays, which are essentially heat rays. Even as far back

as the fourteenth century, it is told of John of Gaddesden, the Court physician to Margaret, second wife of Edward I., that he cured the prince of the smallpox by enveloping him in scarlet clothes and having the bed and all the furniture of his chamber of a bright red colour. The red hangings, being opaque to the actinic rays, prevented them reaching the skin and aggravating the smallpox lesions and, in consequence, the pitting and disfigurement were greatly reduced. Experiments with this mode of treatment made of late years in a smallpox hospital in America corroborated this observation, but had to be discontinued on account of the irritating effects of the red surroundings on both the patients and the nurses.

Sunburn.—Sunburn varies in degree from a slight darkening of the skin to a deep bronzing and occurs more readily in fair than in dark skins. It appears rapidly after the exposure to the sun and soon fades in the absence of strong light.

Sunburn is a diffuse pigmentation due to an increase of the pigment (melanin) in the cells of the basal layer of the epidermis and the deeper prickle-cells, and may be regarded as an effort on the part of nature to protect the deeper layer of the skin, which contains the delicate nerve-endings and the blood-vessels, from the harmful action of the actinic rays.

The degree of pigmentation of the skin varies in different races according to the intensity of the sun's rays to which they are subjected ; in Central Africa,

for example, the native is almost jet-black, in Morocco a lighter brown, in southern Europe olive or brunette, and in Scandinavia blonde. It has been found that when natives with dark skins leave the tropics and come to live in Europe where the sun's rays are less intense, their skins gradually become paler, while if a European becomes resident in the tropics his skin gradually becomes darker.

Acute Solar Dermatitis.—Acute solar dermatitis affects the exposed parts, namely, the face, neck, hands and arms when the sleeves have been rolled up. It is sometimes met with in the legs in children from going about bare-legged, and occasionally in the upper part of the chest and back in adults from wearing a thin white shirt or blouse which is transparent to the actinic rays.

The burn or dermatitis does not appear immediately after exposure to the sunlight but after a latent period of about six hours, when the skin begins to smart and irritate, becomes hot and tense, and an erythema appears which is associated with slight œdema. In mild cases the inflammation, if left to itself, usually subsides in about forty-eight hours, being followed by desquamation and transient pigmentation.

In severe cases the œdema is excessive and may go on to vesication or even to the formation of bullæ. When the face is affected the loose tissue below the eyes may become so œdematous that the eyes are almost closed up and the inflammation, pain, and tension associated with it may be so great as to

resemble erysipelas. In such cases about a week elapses, under the most suitable treatment, before the inflammation subsides.

Sometimes recovery may be prolonged from the occurrence of superficial ulceration, which heals slowly and is followed by atrophy and scarring.

These symptoms are quite independent of the action of the heat rays of the solar spectrum, and can be more readily called forth by the cold reflected light of snow-fields at a high altitude with a temperature far below zero, than by the warmest sun in the tropics.

The degree of inflammation depends, not only on the intensity of the light, but also on the type of skin of the individual affected, people with delicate skins and fair complexions being liable to react much more acutely to the sun's rays than those whose skins are coarser and darker.

After an attack of solar dermatitis has occurred a condition of anaphylaxis, or hypersensitiveness to sunlight, is produced, by which subsequent attacks are liable to follow exposures far less powerful than that which caused the original outbreak.

Pathological Considerations.—The microscopical changes which occur in acute burns from the sun have been carefully studied and have been found to consist of a dilatation of the superficial blood-vessels, exudation of serum, and an infiltration of small, round, mononuclear cells, which is most marked in the neighbourhood of the dilated vessels. In more severe cases, there is marked œdema of the corium with

dilatation of the lymphatic spaces and softening of the white fibrous bundles, and of the epidermis with dilatation of the interepithelial lymphatics, spongy changes in the cells, interference with the process of cornification, and sometimes the formation of vesicles or bullæ.

As a rule, complete recovery takes place by the repair which succeeds the acute inflammatory process. Any destructive changes which may supervene are due to the œdematous degeneration in the cellular elements, or are the result of secondary septic inoculation and superficial ulceration.

Treatment.—The first indication in the treatment of acute solar dermatitis is to soothe the intense irritation and reduce the inflammation. With this object the patient should be put to bed in a cool room, with the light shaded by curtains or blinds, and a saline aperient given to reduce the tension in the skin. Locally the best treatment in the acute stage is the continuous application of a compress or lint mask, soaked in lead lotion, consisting of half a teaspoonful of the Liq : plumbi subacetatis in an ounce of tepid water. Should vesicles or bullæ be present they should be opened aseptically, drained, and a compress of boric acid or aluminium acetate lotion applied.

After the inflammation has subsided the skin tends to peel and become pigmented, but the pigmentation gradually disappears and the desquamation may be counteracted by the application of cold cream.

Much can be done to prevent solar dermatitis in the tropics by the wearing of suitable headgear, ear-caps, veils, and gloves, and by the use of umbrellas or parasols. These should all be orange, red, or brown in colour, and not white or green, since reddish materials allow only the harmless heat rays to penetrate and are opaque to the injurious chemical rays. A useful type of parasol for this purpose is of white cotton lined with red.

In mountaineering in the snow the skin can be protected from the intense light rays, which are partly direct and partly reflected, by covering it with brown grease paint or with lanoline dusted over with a powder containing some reddish-brown substance, such as red bole or turmeric.

Chronic Solar Dermatitis.—This type of solar dermatitis corresponds closely to chronic X-ray burns but is less severe. It is seen chiefly in middle-aged and elderly white men who have had a long open-air life in tropical or sub-tropical countries as planters, soldiers, ranchers, etc., and have been exposed in the course of their work to the brilliant sun day by day. It is particularly common in Australia among men on sheep stations, and is met with also not infrequently in sailors in whom it is partly caused by direct sunlight and partly by the reflected glare from the sea. It attacks the backs of the hands and the face and is characterised by a dry, atrophic, and freckled condition of the skin, which may be slightly scaly, and presents occasional

telangiectases and small horny thickenings which have a tendency to become malignant.

Treatment.—The treatment consists of protecting the exposed parts from the sun by shady hats, gloves, etc., and of avoiding the irritation of the affected skin by the too frequent use of soap and water. At the same time, the skin should be kept soft and pliant by occasional applications of cold cream.

The horny growths, when small, may be reduced by painting them with 2 to 5 per cent. salicylic collodion, by the application of salicylic plaster, or by refrigeration with solid carbon dioxide. If they are large and liable to be irritated by friction, or should they show any tendency to develop malignant characteristics, they should be excised.

CHAPTER X

BURNS FROM CORROSIVES

Introduction.—Strong acids and caustic alkalies have a destructive action on the skin and underlying tissues and give rise to burns which may go on to ulceration and necrosis. The corrosives which are most commonly responsible are nitric, sulphuric, hydrochloric and carbolic acids, "Greek fire" (phosphorus dissolved in carbon disulphite), lime, caustic potash and caustic soda.

Burns from corrosives may be inflicted purposely, as where vitriol or some other strong acid is thrown in the face with criminal intent to produce disfigurement or blindness; or accidentally, as where acid is spilt in the filling of carboys, or where a vessel containing it is broken. The injuries produced are similar in their general appearances, but may sometimes be differentiated by staining of the skin which may be characteristic of the acid or alkali responsible for them.

They are distinguished from burns due to heat by being more uniform in character and by not giving rise to the formation of vesicles or bullæ—except

when produced by Greek fire, in which case vesication may result from the rapid oxidation and burning of the phosphorus.

Lesions due to acids are more circumscribed than those produced by caustic alkalies, as the acid coagulates the albumen in the tissues and so limits the spread of the burn.

Symptoms.—The corrosive causes an actual destruction of the skin, affecting the epidermis and the corium, leading to desquamation, the formation of an eschar, and, in severe cases, to sloughing and ulceration which on healing is followed by scars and sometimes by unsightly deformities—the scarring from corrosives being more marked than that from burns of the same degree due to heat.

Where the corrosive has reached the eye serious injuries to the conjunctiva may result, or loss of vision from dense corneal opacities or from injury to the anterior chamber. Fortunately, in most cases only small quantities of the corrosive reach the conjunctiva owing to the protective action of the eyelids and eyelashes.

Should it be swallowed, more or less severe burns are produced in the mucous membranes of the mouth, throat, gullet and stomach, and sometimes in the larynx. The lips and mucosa may be denuded, or may present the appearance of being coated over with a whitish or coloured membrane, and are generally more or less inflamed, swollen, and œdematous. The usual symptoms due to the swallowing of corrosive fluids supervene, such as shock, intense

pain, retching and vomiting of shreddy matter tinged with blood, and interference with breathing should the larynx be involved. In severe cases death may occur, either immediately, from extensive destruction of the mucosa, perforation of the stomach, or asphyxia; or later, when the ulcerations have healed—which they do extremely slowly—from starvation, brought about by cicatricial contraction of the œsophagus interfering with the passage of food, or from suffocation due to closure of the larynx.

The membrane which results from swallowing corrosives is distinguished from that due to diphtheria by being present anywhere on the buccal mucosa instead of being confined to the tonsils and their neighbourhood.

Staining of the Skin caused by Acids and Alkalies.—Carbolic acid causes an initial white, puckered appearance of the skin and a greyish coating on the mucous membranes. It may also lead to superficial gangrene.

Glacial acetic acid causes a whitish or yellowish stain, especially about the mucosa of the mouth.

Hydrochloric acid stains the skin a greyish-yellow and the clothes a bright yellow which fades to a dirty reddish-brown.

Nitric acid usually stains the skin and the clothes a yellowish tint.

Sulphuric acid stains the skin and the clothes red if dilute, and a dirty reddish-brown or blackish tint if strong.

Caustic alkalies, such as caustic soda and caustic

potash, stain the skin reddish or dirty brown and, when swallowed, cause the mouth and tongue to be swollen and covered with a membrane, which may separate and leave a superficial ulceration. They are also liable to affect the nails if they come in contact with them, rendering them dull, opaque, irregular, soft, thickened, and torn at the edges.

Treatment.—The treatment of burns from corrosives consists of immediately irrigating the burn, either with water so as to wash away any of the irritant which may remain, or with a neutralising solution to counteract it, such as lime water or some other alkaline solution where an acid has been responsible, and vinegar and water, lemon juice, etc., in the case of an alkali.

After the burn has been washed it should be treated on the same lines as burns from heat and simply powdered over with stearate of zinc or other bland powder, or dressed with a 1 per cent. solution of aluminium acetate.

In the case of the eyes it is of the first importance to irrigate them immediately, either with quantities of water or with a neutralising lotion. Where the burn has been due to lime, any solid particles should be removed with forceps or with a spud and the conjunctival sac washed out with boric lotion.

Other Substances which have a Caustic Action

Antimony.—Antimony, in the form of antimonium chloride solution, corrodes the skin and may give rise to necrosis or superficial ulceration.

Arsenic.—Arsenious acid in the form of a paste is a well-known caustic which was once extensively employed for the destruction of superficial new growths. A persistent type of ulceration is produced by the sulphide of arsenic which is met with not uncommonly in the fingers of those employed in cleaning furs with it, and occasionally in workers in tanneries, who use a combination of lime and sulphide of arsenic to remove the hair from hides.

Calcium Carbide.—Carbide of calcium may cause burns in the form of punched-out ulcerations, which are seen occasionally in those who handle it in the making of acetylene gas.

Chromic Acid.—Chromic acid has a caustic action, causing the formation of ulcers wherever it comes in contact with the skin. It may also attack the nose, giving rise to a chronic but painless type of ulceration known as the " chrome ulcer," which generally goes on to perforation of the septum.

Ulceration and necrosis from chromic acid are met with in painters from the use of yellow or red chrome ; in French polishers from the employment of bichromate of potash ; in compositors and autotypers from using it for cleaning type and plates ; and in its most severe form in workers in chrome works, chiefly in connection with the manufacture of potassium chromate.

Hydrogen Fluoride.—Watery solutions of hydrogen fluoride and hydrofluoric acid, on coming in contact with the skin, give rise to a burn in the form of a bullous dermatitis, which may be followed by more or less severe ulceration.

Nitroglycerine.—Nitroglycerine is a mixture of sulphuric acid, nitric acid, and anhydrous glycerine, in the making of which intractable ulcerations about the fingers are liable to be produced.

Malingering from the use of Corrosives (Dermatitis Artefacta)

Self-inflicted injuries of the skin produced by corrosives or strong irritants are by no means uncommon, and to such lesions the name "Dermatitis artefacta" is generally applied. They are usually met with in nervous girls or young women, but may also be encountered in weaklings and malingerers of the male sex.

In women they are usually associated with a markedly neurotic temperament, either natural or acquired as the result of some debilitating illness, which is evidenced by frequent attacks of hysteria, occasionally by anæsthetic patches in the skin or complete anæsthesia of the soft palate, and sometimes by a highly sensitive neuro-cutaneous reflex on account of which the skin reacts so readily to external stimulation that artificial lesions can be produced without arousing suspicion. In other cases, the patient may be phlegmatic rather than neurotic, and appear to be in excellent general health.

Motive.—As a rule, the underlying motive is to excite sympathy or avoid work, and is patent or easily ascertainable, but there are cases in which it baffles the most vivid imagination to discover it, as

when it occurs in individuals who are slightly peculiar, on the border-line of insanity, or under the influence of some subtle psychical disturbance or perverted emotion. In men, in whom it is met with chiefly among artisans, labourers, soldiers, sailors, beggars and criminals, the most common motives are to shirk work, to evoke sympathy, or to obtain insurance benefits or compensation.

Occasionally the idea of producing the lesions is suggested by the previous legitimate use of some irritant, which had caused a dermatitis on account of which the individual had been prevented from working and received undue sympathy; while in other cases it occurs in connection with occupations which necessitate exposure to irritating substances liable to cause dermatitis, when the workers may indulge in unnecessary exposures in order to aggravate or perpetuate the condition.

Symptoms.—The lesions are usually few in number and vary greatly in character, according to the agent used and the manner of its employment. They may be simple erythematous patches more or less covered with crusts, groups of vesicles like eczema, bullæ on inflammatory bases, parchment-like necrotic areas, superficial ulcerations which generally have a well-defined irregular border and on healing are followed by scarring, or ill-defined sloughing or gangrenous sores. Doubtless many of the cases which have been described in the past under the heading of "neurotic gangrene" belong to this last category.

In shape they vary indefinitely. They are not infrequently oblong and situated in the long axis of the limbs, horizontally across the chest, or slanting down the sides of the abdomen, in which case they have usually been produced by the rubbing in of some irritant, such as turpentine, spirit, or urine, by the fingers.

Sometimes they present the shape of the agent used in making them, as when they have been caused by a penny soaked in vinegar or by a piece of mustard plaster.

The most common sites for them are the antero-external aspects of the limbs, the face, and more rarely the trunk. They are frequently limited to one side of the body, and usually to parts accessible to the right hand.

Agents.—A great variety of agents have been used to produce them, and it may be difficult or impossible to identify the one employed from the appearance of the lesions. Those most frequently resorted to are corrosives and irritants, such as carbolic acid, acetic acid, common salt moistened, caustic soda, croton oil, cantharides, arnica, turpentine, saliva, and urine.

Diagnosis.—As a rule, there is no great difficulty in recognising lesions of this type. They usually have something peculiar in their appearance, distribution, or course, which differentiates them from any ordinary skin affection. They tend to come out suddenly and at irregular intervals according as the patient has the opportunity and the privacy to produce them and, as would be expected, they are most liable to be caused

during the night and to be found in the morning. When some caustic has been the agent, its odour may cling to the lesions and evidences of it may be seen in the neighbouring skin, clothes, or on the fingers. Where a strong acid or alkali has been employed, a clue may sometimes be obtained by testing the reaction of the lesions with a piece of litmus paper.

As a rule, they heal readily under a fixed dressing, while fresh ones keep on appearing beyond the dressing or in some other region.

In many cases the type of patient is an aid to the diagnosis, for they are often neurotic or peculiar, have a furtive look when questioned and may show other signs suggestive of malingering.

Treatment.—The treatment of cases of Dermatitis artefacta is often most difficult, for the ingenuity, perseverance, and fortitude of this class of patient are often remarkable and the lesions may be kept active or new ones produced indefinitely until the patient either obtains the special object he desires, or gives it up as hopeless, or is deterred by the disfigurement from the procedure becoming intolerable.

When malingering is suspected, but difficult to prove, the co-operation of an intelligent nurse or attendant may be of the greatest assistance in establishing it.

The treatment of the actual lesion is simple and varies according to the type of lesion. It consists of soothing or antiseptic applications under occlusive dressings. One of the most serviceable dressings for

this purpose, where the lesions are neither moist no septic, is zinc gelatine paste, which consists of gelatin 15 per cent., glycerine 10 per cent., zinc oxide 25 pe cent., water 50 per cent.; this is melted and painte on with a brush, and on drying forms a coating ove the inflamed patch or necrotic area under which healin rapidly takes place. Any attempt to remove it i order to aggravate the sore can generally be detecte

BURNS FROM CORROSIVES

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CHAPTER XI

DERMATITIS FROM HIGH EXPLOSIVES

Dermatitis, or inflammation of the skin, occurs in connection with a large number of occupations, and may be met with in practically every one in which irritating substances are liable to come in contact with the cutaneous surface. It varies in degree from simple erythema to œdema, vesication, or even bullous formation. A considerable number of cases have occurred during the present war in munition works where high explosives are made, from the action on the skin of substances such as trinitrotoluene, tetryl, etc., and it has been considered advisable to include here a brief description of their irritative and toxic effects.

Fortunately, these cases of dermatitis are much less frequent than they were at the beginning of the war, since they have been thoroughly studied and every precaution taken to prevent their occurrence by greater care and cleanliness in working; while at the same time the serious effects which used to accrue in them from secondary septic complications are now almost unheard-of as

the dermatitis is immediately recognised and properly treated.

This subject is of great importance in munition factories working at high pressure; for not only may the dermatitis necessitate cessation from work until a cure has been effected, but it may render the skin so sensitive that the slightest subsequent exposure to the irritant may determine a recurrence, and it may even entail a change of employment, as repeated attacks are liable to develop into a persistent and intractable eczematous condition.

Trinitrotoluene (T.N.T.). *General Considerations.*—Trinitrotoluene is an explosive which is solid at ordinary temperatures and is easily reduced to a fine powder or dust. It melts at about 80° C., when it gives off fumes, and is soluble in oils, ether, acetone, xylol, etc.

In sieving and filling canisters or shells with the powder the operators are apt to be covered with a fine cloud of dust, which insinuates itself over the tops of stockings and socks and down the neck, reaching covered parts of the body and giving rise to a severe form of dermatitis. It is liable to be absorbed through the skin, when it may lead to serious and sometimes fatal toxic symptoms. It may also be inhaled or swallowed and cause irritation of the gastric mucosa or the mucous membrane of the upper air passages, but the irritative symptoms are transient, as the mucous membranes readily become tolerant to it.

Sometimes inhalation of the fumes from molten

trinitrotoluene has been cited as a cause of the toxic symptoms, but this is rare in comparison with absorption through the skin.

Dermatitis and internal toxic symptoms seldom occur together, and it has been suggested that when a dermatitis is set up it either prevents the absorption of the powder or neutralises it by the inflammatory reaction of the skin.

Trinitrotoluene, when mixed with 50 per cent. of ammonium nitrate, is known as amatol, and with 20 per cent. of ammonium nitrate as ammonal. According to an official communication from the Ministry of Munitions, of the cases in which jaundice occurred 20 per cent. have arisen from pure trinitrotoluene and 67 per cent. from amatol, and it is believed that the hygroscopic nature of the ammonium nitrate assists its absorption through the skin.

Symptoms. *Local Effects.*—In mild cases the dermatitis consists of superficial erythema of a patchy character followed by fine desquamation; and in severe cases of more or less marked œdema and a papulo-vesicular or bullous eruption, like dysidrotic eczema or Cheiro-pompholyx, which may be followed by a coarse exfoliation of the skin, especially of the palms. If the vesicles or bullæ be not properly treated they are apt to become secondarily infected with pyogenetic cocci, and suppuration or even superficial ulceration may result. Associated with the dermatitis there is more or less intense itching.

In addition to the inflammation there is a yellow or tawny-orange staining of the skin and hair, which

is specially noticeable in the creases of the palms, where it may be so marked as to stand out in bright yellow lines, and which may persist for weeks after exposure to trinitrotoluene has ceased. It can be changed by alcoholic potash to a pink or purple tinge, when it is soluble in water and can easily be washed out.

As would be expected, it is the exposed parts, namely, the hands, wrists, face, and neck, which are most liable to be affected, the dermatitis being specially marked where the skin has been chafed by tight bands as about the wrists and neck. It may also occur on the feet and ankles from trinitrotoluene dust on the floor, and may be met with occasionally on the groins and upper parts of the thighs.

The dermatitis, though severe, does not as a rule interfere with the general health, and heals quickly under suitable treatment with no ill-effects.

General Effects.—An important discussion on the toxic effects of trinitrotoluene took place at the Royal Society of Medicine in January, 1917, a summary of which was given by the chairman, Surgeon-General Rolleston, R.N., C.B.; to this the writer is largely indebted for a description of the general symptoms produced by an absorption of the explosive.

The general effects of trinitrotoluene poisoning are grouped under the headings of toxic gastritis, toxic jaundice, and toxic anæmia.

(1) **Toxic Gastritis.**—This is the most common constitutional effect of the absorption of the ex-

plosive powder and is evidenced by general depression, cyanosis of the lips, sickness, vomiting, pain in the epigastrium, constipation, distension of the abdomen, and high-coloured urine containing trinitrotoluene.

Note.—The urinary test for trinitrotoluene is known as Webster's Test; the following description of it is quoted from a communication from the Ministry of Munitions which appeared in the *British Medical Journal* of December 16th, 1916, on page 845.

"*Webster's Test for Presence of T.N.T. in Urine.*

"Measure out 12½ c.c. of the urine in a measuring cylinder, then add 12½ c.c. of diluted sulphuric acid, made up by mixing 20 c.c. of strong sulphuric acid with 80 c.c. of water. Pour the mixture of urine and acid into a separating funnel of 100 to 150 c.c. capacity and provided with a stopcock; add to the mixture 10 c.c. of ethylic ether (the ordinary ether made from methylated spirit is sufficiently pure for the purpose), shake up well and allow to settle; take out the cork or stopper from the top of the separating funnel, open the stopcock at the bottom and allow the mixture of acid and urine to run off, then turn the stopcock off so as to retain the ethereal solution in the separating funnel. Now add 25 c.c. of tap water to the ethereal solution in the separating funnel and shake up again to remove the traces of the mixture of urine and acid and allow to settle again for two or three minutes, then run off the water by opening the stopcock, retaining the ether in the funnel. Finally, let the ethereal solution flow into an ordinary test-tube and try for the presence of T.N.T. in it as follows:

"Prepare a solution of alcoholic potash by dissolving 4 to 5 grams of caustic potash in 100 c.c. of methylated spirit or absolute alcohol. Where many tests are to be carried out this solution may be made by having a stock saturated solution of caustic potash, and adding, when a fresh quantity of the reagent is required, 10 c.c. of this to 90 c.c. of alcohol.

"To the ethereal solution obtained as above described 5 c.c. of this alcoholic solution of potash are added. When T.N.T. is present a purple coloration is at once developed, varying in intensity according to the amount of T.N.T. present, from the faintest trace to a deep purple. The colour changes rapidly from the purple to a brown colour, and it has been found that the best results as to intensity are obtained by judging rapidly after the colour is struck."

(2) **Toxic Jaundice.**—This is much less common than toxic gastritis. It does not usually appear until two or three weeks after beginning to work with the trinitrotoluene, and may even be delayed for a considerable period after ceasing employment, in which case it may possibly be due to continued absorption of the explosive, which may still be clinging about the hairy scalp or the underclothing.

The onset is usually quite sudden, though it may be heralded by drowsiness, depression, and dark urine. The jaundice is usually of the simple catarrhal type, with slow pulse, bile in the urine, constipation, and occasional albuminuria or intermittent glycosuria. In severe cases, a fatal issue may supervene from hepatic insufficiency, the end being preceded by hæmorrhages in the skin and convulsions.

(3) **Toxic Anæmia.**—In the majority of cases no definite changes occur in the blood, but occasionally a grave and even fatal anæmia may develop, in which there is definite leucopenia, a lower percentage of polymorpho-nuclears and a relative lymphocytosis.

Etiology.—Idiosyncrasy or individual susceptibility is an important factor in the etiology of this form of

dermatitis. Some skins are proof against the ill-effects of the explosive unless they are subjected to more or less continuous exposure to it or their resistance is lowered by the occurrence of some other form of inflammation, such as eczema or impetigo; while others are so liable to it that it makes its appearance within the first week of contact with the irritant and recurs with every subsequent exposure, however slight.

It has been stated that it affects both sexes equally; one would expect it, however, to be more frequent in women than in men, as their skins are usually more delicate.

It is most common in the hot weather and when the skin is flushed and moist with perspiration, as when sweating is profuse the sweat is alkaline in reaction and acts on the trinitrotoluene, causing it to stain more deeply and increasing its toxic properties.

As the trinitrotoluene is soluble in oils, the dermatitis is particularly apt to occur when the skin is greasy.

Treatment.—As soon as the dermatitis appears the patient must stop work and avoid further exposure to the irritant until complete recovery has taken place. However mild the case may be, it is of importance, in the first instance, to remove all traces of the trinitrotoluene which may be adherent to the skin or hair by gentle rubbing with one or other of the solvents, such as ether.

If the dermatitis be slight, it usually yields to calamine lotion followed by the application of a

bland zinc paste, such as equal parts of zinc, starch, lanoline and vaseline.

If the irritation be intense, relief may be obtained from the application of lint soaked in a weak tar lotion, about a teaspoonful of the Liq: picis carbonis to half a pint of water ; when this is removed the skin should be dusted over with a bland zinc oxide powder.

Should the skin be broken by the rupture of vesicles or bullæ, a boric compress or a mild antiseptic ointment containing 2 per cent. of ammoniated mercury should be applied continuously to prevent suppuration.

The general treatment of the toxic gastritis and toxic jaundice is thus summarised by Rolleston: "The treatment consists in removal from work, rest in bed for a day or two, milk diet with alkalies (10 gr. increased to 2 dr. of sodium or potassium bicarbonate to each pint of milk) to combat acidosis, demulcent drinks such as barley water, and the correction of constipation."

No effective treatment has yet been found for the toxic anæmia.

Prevention.—Every care must be taken in factories to avoid spilling the powder on tables and floors or allowing it to fall on the outside of bombs and shells.

Scrupulous cleanliness should be insisted upon in the workshops, and the workers should be instructed to wash the face and hands before meals and before leaving the factory, and any of the powder which is adherent to the skin or hair should be dissolved off by oil, ether, or other solvent.

The workers should protect themselves by wearing wash-leather gloves with gauntlets, caps, and an overall which should fit closely at the wrists and neck without open slits. The wearing of muslin veils has been advocated, but these irritate the wearers by obstructing the vision and are generally discarded. On reaching home they should have a complete change of clothing and must on no account sleep in any garment worn at the factory.

It is important that the general condition of the workers should be maintained at as high a level as possible, open air exercise should be encouraged and substantial meals provided, as it has been found that the cases are fewer and less severe in the well nourished than in those who are having insufficient or improper food.

Tetryl or Compound Explosive.—Tetryl is a virulent skin irritant which causes dermatitis in a considerable percentage of those working with it. In its chemical composition tetryl is trinitro-phenyl-methyl-nitramine, and it occurs in the form of a fine yellow powder and in coarse dark crystals or granular masses. It is in the powdery form that it is most potent as a mechanical irritant, as it is composed of fine crystals with sharp edges, which have no great tendency to agglutinate. The powder is given off in the process of sieving the compound, and becomes deposited on the exposed parts of the skin and so sets up a dermatitis.

Tetryl causes a yellow or apricot discoloration of

the skin and hair which may appear in the hands on the first day of working with it, and on the face a few days later. It is more liable to occur in people with moist skins who sweat profusely than in those whose skins are naturally dry, as the tetryl is soluble in the alkaline sweat.

The dermatitis, which usually comes out within a fortnight of commencing to work with the tetryl, varies from simple erythema to marked œdema or vesicular formation and is associated with itching of a continuous and distressing nature, which may prevent sleep, and occasionally with septic complications from secondary infection.

As a rule, it attacks only the exposed parts and is usually more marked on the face and sides of the neck than on the hands, but it may also affect covered parts when the powder has been able to insinuate itself beneath loose clothing.

The eyelids are apt to be severely involved, partly through being rubbed in an effort to relieve irritation, and become puffy, œdematous, and sometimes so swollen as almost to close the eyes, while the irritation of the conjunctivæ may be so severe as to lead to acute inflammation and a copious discharge.

Occasionally, the feet may become affected from tetryl dust about the floor getting inside the shoes and working its way through the stockings.

Once an attack of tetryl dermatitis has occurred the skin becomes so abnormally sensitive to it that even if the worker be transferred to another department a recurrence may be determined by contact with clothes or even with paper soiled with tetryl.

It has been met with, not only in workers with tetryl, but in those who live with them, and this has been attributed by Enid Smith to the washing of the worker's clothes with hot water, the steam from which is irritating from particles of the explosive powder suspended in it.

In addition to the dermatitis, symptoms of irritation may be caused in the mucous membranes of the stomach and upper respiratory passages from swallowing or inhaling the powder, and it may give rise to pain in the epigastrium and vomiting of bile, on the one hand, and to sneezing, epistaxis, occasional asthmatic attacks, and in rare instances to headache and giddiness, on the other.

Even in the most severe cases symptoms of absorption are absent as a rule, and if they do occur are transitory, and there is no instance of its having resulted in toxic jaundice or other serious toxic symptoms such as are met with in connection with trinitrotoluene.

Treatment.—The dermatitis heals rapidly when the worker is removed from exposure to the tetryl and simple local treatment is instituted, and the staining soon disappears.

It is important that it should be recognised early and promptly dealt with to avoid septic complications.

Œdema may be reduced by calamine lotion or cold compresses, but lead lotion should not be employed owing to its affinity to the tetryl.

Where vesication has occurred and discharges or

crusts are present, the skin should be bathed with boric lotion or cleaned with olive oil and a dressing of calamine cream or zinc paste applied.

For the conjunctivitis the eyes should be irrigated with boric lotion, and an astringent, such as collosol silver, used to reduce the inflammation.

Prevention.—The workrooms should be kept cool, well-ventilated and scrupulously clean, and the tables and floors regularly scrubbed and swept. Overalls of some glossy material should be worn which fit closely at the wrists and neck and, before leaving, these should be removed, the skin thoroughly washed, and outdoor clothes put on.

As prophylactic measures, hardening the hands in methylated spirit and the application to the face of a bland powder, such as equal parts of zinc oxide and starch or prepared chalk, have been recommended.

On no account should persons be employed who are suffering from inflammatory affections of the skin, such as eczema, psoriasis, or impetigo.

Fulminate of Mercury.—Fulminate of mercury is a high-explosive preparation of mercury. It is in the form of a powder which has an extremely irritating effect on the skin and gives rise, soon after exposure to it, to an acute papulo-vesicular dermatitis about the hands and forearms and to a red, blotchy dermatitis on the face, chiefly affecting the forehead, cheeks and around the eyes. In severe cases the vesicles may coalesce to form bullæ, which on drying

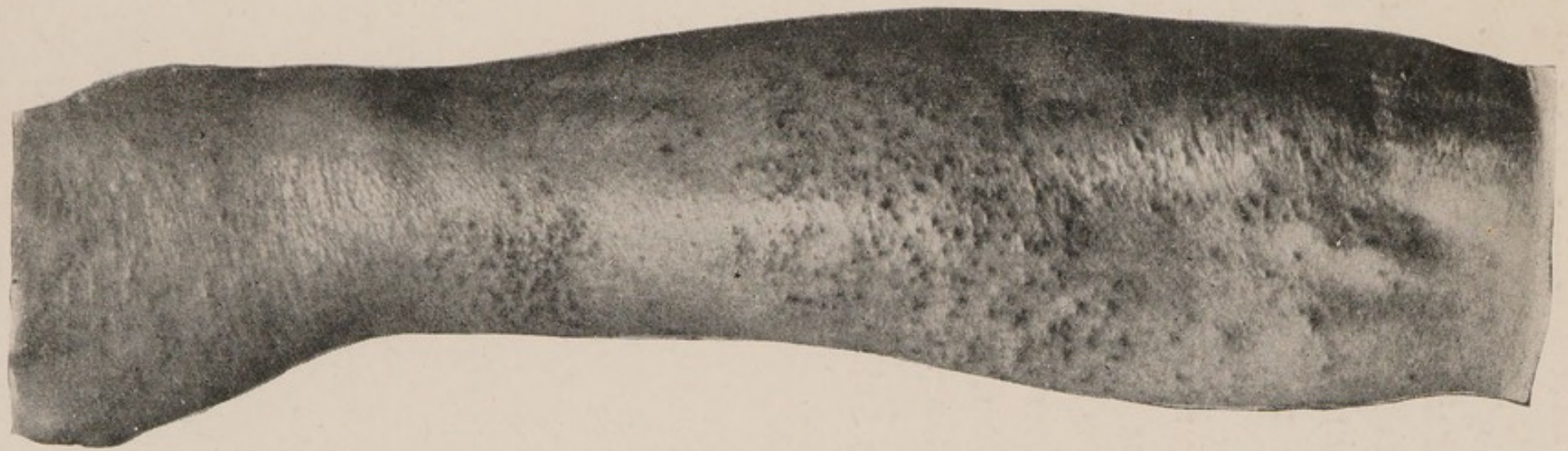

FIG. 18.—Papular dermatitis of forearm caused by fulminate of mercury.

up are followed by a coarse exfoliation. The dermatitis is associated with intense itching.

The powder has to be moistened and rubbed up into a paste by certain of the workers, who are liable, in consequence, to a dermatitis of the hands of the dysidrotic type, which may be accompanied by corrosive ulcers about the tips of the fingers and destructive changes in the neighbourhood.

On ceasing to work with the irritant, the dermatitis heals rapidly under mild antiseptic applications, such as those employed in the treatment of dermatitis from trinitrotoluene.

Lyddite (Picric Acid).—Lyddite, which is made from picrate of potash, has an irritating action on the skin from the picric acid it contains, and gives rise to an acute form of dermatitis very similar to that caused by trinitrotoluene. As a rule it is especially marked on the hands and forearms and is accompanied by a canary-yellow or greenish staining of the skin. Like tetryl it produces no constitutional symptoms, and its treatment is similar.

Hexa - Nitro - Diphenyl - Amine.—This explosive is closely related to aurantia, an orange-coloured, basic aniline dye used in dyeing leather. It is responsible for a form of dermatitis which was met with first in this country in connection with the air-raids in June, 1917, when a number of cases occurred as the result of handling a powder, believed to be a mixture of this substance and trinitrotoluene, which was contained in the high explosive bombs dropped in these raids.

A typical case came under the observation of the writer in the Skin Department at Charing Cross Hospital in a Royal Naval gunner, who was detailed by the Admiralty to remove the detonator from an unexploded bomb which had crashed through a house in the East End of London and buried itself 7 feet deep in loose earth in the basement. He had to dig away the earth in the dark and on reaching the bomb to unscrew and remove the fuse, and in so doing the loose powder from the exploder fell on his hands and caused the dermatitis. He was seen on the eleventh day after this happened, when the hands were found to be stained an orange colour, were swollen and œdematous, felt hot and tense, and presented deep-seated vesicles and small bullæ between the fingers and on the dorsa like those of dysidrotic eczema. The condition in some ways recalled the dermatitis from tetryl, of which a number of cases in munition workers had been under treatment in the clinic at about the same time.

Cases of this nature were reported by J. H. Sequeira, H. G. Adamson, and others, the clinical characteristics of which were so constant as to point to the condition being a distinct form of dermatitis.

In all the cases the staining of the skin took place at the time of contact with the explosive, while the dermatitis did not appear until after a latent period of about ten days. On the ninth day irritation of the skin developed, which was sometimes so severe as to prevent sleep, and an eruption of deep-seated vesicles, like those of dysidrotic eczema, made its

appearance on the palms and sides of the hands and fingers, in the inter-digital clefts, and sometimes on the soles and between the toes. This eruption increased, and usually reached its maximum between the twelfth and fourteenth day. It was not associated with much inflammation, but there was generally an œdematous swelling of the backs of the hands. The vesicles tended to coalesce to form bullæ, varying in size from a large pea to a hen's egg, which occasionally became septic through contamination of the contents with pyogenetic cocci. In about a week they generally dried up and the dead epidermis desquamated in flakes, leaving a shiny pink surface covered with newly-formed epidermis.

The face was sometimes involved, when the eruption presented an eczematous appearance.

Treatment.—The affected parts should be bathed in warm water or in a weak alkaline solution, consisting of bicarbonate of soda and water, half a teaspoonful to the pint, to remove any of the explosive powder still present on the skin. Calamine lotion or calamine cream consisting of calamine 1 dr., zinc oxide 1 dr., almond oil 1 oz., and lime water 1 oz., should then be freely applied to the skin, and later zinc paste may be substituted.

Under this treatment healing generally takes place in two or three weeks.

Should the skin have become septic it should be sprayed with perchloride of mercury solution (1 in 2,000), acriflavine solution (1 in 1,000), or bathed with boric lotion.

FIG. 19.—Dermatitis from explosive powder from bomb dropped in air-raid, showing swelling from œdema, and vesication. The dermatitis appeared ten days after contact with the powder.

DERMATITIS FROM HIGH EXPLOSIVES

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