

## REMARKS

ON

BURNS BY GUNPOWDER AND SCALDS  
BY STEAM.\*BY WILLIAM R. E. SMART, C.B., M.D.,  
Inspector-General, Haslar Hospital.

DURING the China war of 1857-1858, I treated in a ship-hospital twenty-one cases of severe burns by powder-explosions. They were all burnt in the face, neck, hands, and extremities, but not on the trunk. There were six deaths, on the seventh, tenth, fifteenth, seventeenth, eighteenth, and thirtieth days respectively.

In surveying these cases, the remarkable points are: 1. The great extent of burnt surface curable; 2. The amount of nervous shock, and its long continuance, even on the second day; 3. The great secondary or suppurative fever, with delirium (often noisy); 4. The high amount of gastro-enteric and dysenteric disturbance.

The case that died on the seventh day is thus noted:—J. B. Burn, head severely; hair singed off; face black, masked; eyelids closed and tense; all features obliterated. Second day. Hissing respiration; neck, arms, and hands swollen and vesicated; feet, legs, thighs, scrotum, and penis, all much burnt and vesicated. Fourth day. Suppuration commenced; ophthalmia. Fifth day. Sloughs fixed on face; sloughy patches from nates to ankles; suppurative action in legs, thighs and scrotum; apyretic; requiring a laxative. Sixth day. Pyrexia, with restless delirium, frequent pulse, furred tongue, thirst. Vespere. Muttering; tossing clothes; hot skin; feeble pulse; dyspnoea and great general prostration. Seventh day, 9 A.M. Exhaustion. Expired tranquilly, without convulsion or coma.

*Case of Death on Eighteenth Day.*—E. W., severely burnt on head and neck; face masked in gunpowder-eschars; eyes closed, lower lids everted; lips swollen, and burnt inside; upper extremities much scorched; the knees and thighs (lower) less so. Second day. Moaning drowsily. Vespere. Hands cold; gangrene of a finger; pus from eyelids. Third day. Forearms tumid and red above burns. Fifth day. Pyrexia; erythema around thighs. Tenth day. Diarrhoea, with tormina and tenesmus. Eleventh day. Suppuration very free. Thirteenth day. Stools sero-feculent and shreddy, with tormina; tongue dry and furred; sloughs detaching by suppuration. Evening. Prostration, with delirium. Fourteenth day. Exhaustion advancing; suppuration decreasing; sordid lips and teeth. Fifteenth day. Diarrhoea continues, with irritable stomach. Sixteenth day. Moaning; restless all night; purging. Evening. Conscious, and replying. Seventeenth day. Sinking; blood oozing from hands. Eighteenth day. Expired at 3 A.M.

*Case fatal on Thirtieth Day.*—H. P. Burn, face, neck, and upper extremities severely; face masked; eyelids and nostrils occluded. Second day. Eyes and nostrils discharging a muco-purulent secretion; restlessness; dyspnoea; wheezing inspirations. Fourth day, evening. Deglutition painful and difficult; extremities cold. Fifth day. Dysphagia; prostration; pulse feeble and frequent; commencing suppuration. Sixth day. Delirious; restlessness; hot dry skin; urgent thirst; sloughs detaching. Tenth day. Constant low delirious muttering. Eleventh day. Irritative fever; restless delirium; all limb-sloughs separated; general suppuration. Eighteenth day. Face masked and painful; contraction commencing in flexors of fingers, wrists, and elbows; rapid feeble pulse; sordid lips and teeth. Nineteenth day. Sense of extreme prostration; deep ulcers in place of the sloughs; sloughing bed-sores. Twenty-first day. Sleeps sounder; coherent when awake. Twenty-fifth day. Ulceration of right cornea; anterior chamber filled with pus. Twenty-sixth day. Comatose; passing stools involuntarily. Twenty-seventh day. More intelligent; cornea has burst. Twenty-eighth day. Urine scanty, thick, and dark-coloured. Twenty-ninth day. Coma; subsultus; muttering delirium; ischuria. Thirtieth day, 4 A.M. Awoke with a sense of dissolution, jactitating and screaming; desire to micturate; bladder empty. 10.45 A.M. Expired.

These three fatal cases of burn are typical of the pathological conditions preceding death in the stages subsequent to the passing off of shock. The first died in the primary reaction, with signs of acute meningeal congestion, on the seventh day; the second, in the suppurative fever, with enteric complications that assumed the dysenteric type,

that probably would have been gastro-duodenal in a non-dysenteric climate, on the eighteenth day; the third, by exhaustion of nerve-force and blood-poisoning, ending in renal suppression, on the thirtieth day.

In another, that died on the tenth day, there was much nervous shock, subsiding into delirium on the second night. It calmed down next day, to reappear on the seventh, after which sloughs commenced to form on the heels, insteps, and ears.

A case, fatal on the fifteenth day, had been badly burned. On the sixth day, the scrotum, nates, and thighs were suppurating; and next day he had fallen into a state of restless, groaning, talkative delirium, attempting to leave his bed; which state continued to the last. On the thirteenth day, there was hæmorrhage under detaching sloughs on the scalp; on the morning of the fourteenth day, trismus, with tonic contractions of the fingers and wrists; and death closed the scene towards night, amidst diarrhoea, subsultus, typhomania, and efforts to rise.

A case that terminated on the seventeenth day had delirium with stertor. On the evening of the second day followed semi-coma, which passed away. On the eleventh day, he had pyrexia and much pain in the parts burned; on the fourteenth, nausea and retching. On the sixteenth, there was brawny erysipelatous inflammation of the face and scalp; on the seventeenth day, delirious jactitation, with feeble rapid pulse, dry tongue, dyspnoea, death.

It will be pertinent to afford an example of recovery from a degree of injury which, in its first aspect, was appreciably the same in form as in those that perished, but not so near the trunk as in case No. 1.

J. McB. Face, head, neck, arms, and hands partly escharred, and in parts vesicated and tumid; knees, legs, and ankles vesicated. Second day. Nervous depression; hissing respiration, from tumefaction of passages; features obliterated—a black mask; eyelids tumid; ectropium with purulent discharge; dyspnoea and restlessness. Fourth day. Suppuration on hands and feet; eyelids less tumid—could be opened. Fifth day, evening. Pyrexia. Sixth day. Eschars separating from face; sense of exhaustion; constipation. Eighth day. Tongue dry; in other respects the same. Sixteenth day. Ulcers healing; tongue dry; bowels regular; sitting up in bed. Twenty-fifth day. Full diet. Forty-fourth day. Discharged cured.

The case of McB. was as severe as any that finally recovered; he had continued throughout free both from meningeal and from gastro-enteric complications. In other cases, these were present; and the former was found to give less ground for unfavourable prognosis than the latter, as it would rapidly disappear; while the latter was exceedingly troublesome, and its contrary state—constipation—was the most favourable of symptoms. In some, otitis and otorrhœa existed. In some, adenitis of the glands of the neck or groin, and balanitis, occurred, perhaps from incapability of cleansing the part. In the state of shock, the catheter was often used provisionally. Convalescence was apt to be retarded by the readiness with which the new cuticle was abraded or vesicated.

However, out of twenty-one cases of very severe gunpowder burns, fifteen, or over two-thirds, recovered, and only one was invalided to England.

The local treatment used was, as a rule, in the first stages of depression and reaction, by Carron-oil on cotton-wadding; in the suppurative stage by oxide of zinc, and by calamine ointment; in the granulating and cicatrising processes, the same means were continued; but, when the granulations became flabby and pale, much benefit was found in laying on them strips of lint well covered with resinous ointment containing an excess of turpentine.

Our naval history affords many instances of terrible destruction of life by explosions of powder magazines, when the corpses and the dismembered limbs of men have been blown far away from the scene, and the hurt, strewn around the decks, have presented injuries like in every respect to those I have been describing. Since the introduction of steam-power, there have been at rare intervals instances of boiler explosions that have now and then hurled into eternity an individual or two and disabled others; but such a catastrophe as that which lately happened in the stoke-holes of H.M.S. *Thunderer* has been unprecedented. Of thirty-four in the vigour of manhood and pride of life who descended to their post of duty in the stoke-holes after dinner on July 14th only two are alive to tell the tale, and other thirteen, who were slightly removed from the stoke-holes, have added their names to swell the calamity.

In all, about eighty persons were involved, of whom forty-five have perished. The explosion, which has been estimated as equal to that of a 35-ton gun, occurred in a confined space, scattering around huge masses of iron, pouring out tons of boiling water with volumes of intensely heated steam, mixed with the sulphurous and carbonaceous

\* Read at a meeting of the South Hants Branch of the Association.

fumes of suddenly extinguished furnaces, freshly heaped up with live coal, giving a mimic but too near representation of the sudden eruption of a dormant volcano. This happened within one hour of our hospital doors, which were open to receive the living and the dead.

Fifteen corpses, many of them more frightfully mutilated than is rarely seen in battle, and all much excoriated, were drawn out from the scene of disaster, and of those who were extricated alive four died in the passage to the shore. Fifty-eight living sufferers reached their beds in hospital. The majority of those were terribly scalded; some had had their light clothing torn away from their bodies by the force of the penetrating blast of the steam, but only one had received any mutilation—a compound fracture of the lower leg, with ablation of the heel. He survived his injuries about four hours without rallying. Within thirty hours, eleven of his comrades brought with him to the hospital succumbed in the stage of primary shock, some apparently insensible and semi-comatose, others, after imperfect attempts at rallying, deliriously rolling from side to side, breathing heavily from obstructed air-passages, retching and vomiting, and suffering from strangury; in their great distress, using all their efforts to tear from their flayed limbs the dressings that had been laid on.

Those who survived the primary shock and rallied, felt relieved of their scorching agony and gained fitful sleep in from thirty-six to forty-eight hours, passing urine and intestinal evacuations, and some of them asking for nutriment. It is difficult, where so many causes, each sufficient in its way, contributed to fatal results, to assign to each its due weight; but I am of opinion that, in those that succumbed within the first thirty hours, the scalded state of the fauces and glottis was a lesion of paramount importance that turned the balance against recovery, by retarding rallying from the shock of the accident. Unfortunately, no opportunity was afforded of *post mortem* examination to test the correctness of this view.

In some, a semi-comatose condition released them from suffering, but in others the effort of Nature to establish suppurative action was attended with internal organic congestions: that of the nervous centres marked by low muttering delirium, moaning jactitation, involuntary evacuations of the bladder; and that of the gastro-enteric tract by retchings and forcible emptying of the stomach, lapsing into coma and death. In this stage of irritative fever reaction, six perished: one on the fifth day, three on the sixth, one on the eighth, and one on the ninth day after the receipt of injury.

On the tenth day, when thirty-three had perished—fifteen killed, twelve by shock, and six by irritative fever and its organic complications—there remained alive in hospital forty-four still suffering; of these, many lay beyond reasonable hope of recovery, and of these twelve have since died, twenty-seven have been discharged healed of their wounds, and five still continue under treatment, which will in all probability be attended with success.

Of these, J. D. was deeply scalded by steam only over the face and head, and in the air-passages and over the upper extremities. He had been exposed to the first upward rush of the steam through the casing of the funnel, by which he had been blown fifteen feet from the spot on which he stood, and over 350 square inches of the upper part of his body were denuded of cuticle or covered with it in large vesications. On the sixth day, his entire surface was of a livid red colour, like that of scarlet fever of bad type. Until then, he had not become conscious of his condition, and then he lapsed into a state of restless delirium, with frequent fits of moaning. That state of fever reaction lasted until the eleventh day, when he again began to answer coherently; but, on the fifteenth day, he relapsed into delirium, and maintained it up to the twentieth day, when he first inquired where he was, and what it was all about, and recollected, when reminded of it, that he had been on board the *Thunderer*. In the meantime, he had had severe ophthalmia, which had destroyed the left eye and had endangered the sight of the right, which has, however, been restored. Complaining of dysphagia on the twenty-second day, his fauces were found to have small sloughy patches. At the end of the fourth week, he was suffering from gastro-enteritis, with red glazed tongue, retching and vomiting, diarrhoea and prolapsed anus, which began to subside on the thirty-second day. But his dangers had not yet ceased, as, on the fortieth day, the kidneys showed signs of sympathising in diminished secretion, followed next day by changes in its character, darkened with bile-pigment, of acid reaction and high specific gravity, 1.046, without albumen or urinary casts, which subsided into urates and phosphatic deposits, with oxalates in the last stage, after four days of disorder. He is now left with left staphyloma, granulating sores that will leave a few cicatricial contractions on the forearms, hands, and eyelids, which will somewhat disable him through life.

Another case of steam-scald, still under treatment, was in the engineer's galley in the casing of the funnel, and severely scalded to the

extent of 400 square inches. He had no signs of full meningeal inflammation, but, from the stage of suppurative fever at the end of the third week, in which sloughing of the integuments of the fore-arms was present, he had renal irritation, or rather nephritis, masked by secretion of albumen with disintegrated blood-discs, and also attacks of gastric irritation, with retching and vomiting. He is now in a promising condition, with every chance of restoration; maimed in the arms and hands, and with more or less lesion of the kidneys.

I have detailed these as the two worst of the cases that have escaped death, subordinated to which, in degree only, are many of the survivors. Amongst all of them the results of the nervous shock will be slow to disappear, which in some has assumed a sentiment of horror, about what they have gone through, with an insuperable idea that they will not recover their former courage, to render them capable of undergoing similar risks with unconcern and freedom from apprehensions. Many of the recovered cases passed through severe stages of meningeal and gastro-enteric irritation of high degree, and in some there was a minor degree than that detailed of renal complication. In the majority there was a minor degree of the acute congestion of the fauces and air-passages, which had been a prominent symptom amongst those who perished in the primary stage of shock. In several cases there was severe conjunctivitis, terminating by suppuration; and in some there was inflammation of the meatus auditorius, that ended by curable otorrhœa.

There was one very marked condition, in the rarity of sloughing of the deeper integuments, which contrasted strongly with what occurs in burns by the explosion of gunpowder—in which I have known the hair singed to the scalp, and the lighter articles of clothing set on fire, and perhaps the destruction of tissues aggravated by that cause—so that sloughing is a very common sequel, and the danger greatly aggravated thereby; and erysipelatos inflammation is much more frequent after powder-burns than after scalds, even when so severe as these now recorded, and delirium comes on much earlier. But the primary mortality from these forms of injury, from the immediate results of heat, has been much greater in this casualty than I have noted in the instance of gunpowder explosion in the open air. This contingency is, I do not doubt, attributable to the greater amount of surface involved, affecting a much wider extent of a highly endowed nervous tissue, productive at once of such a degree of shock to the nervous centres as cannot be recovered from, precluding the systemic effort to rally from the overwhelming nervous depression. It was remarked to me by a scientific observer, who had been witness to the consequences of two great magazine explosions, that, with eighty square inches of damaged integuments, there was always a degree of secondary fever that involved danger to life. This induced in me a desire to ascertain, by measurement, the extent of scalded surface which did not involve fatal termination; and I placed the inquiry in the hands of a very painstaking zealous officer, Dr. Burke, to make approximate measurements of the surface that had been scalded in all the cases remaining under treatment, in the seventh week after the casualty, with this result in twelve cases, respectively: 198, 213, 232, 265, 283, 345, 355, 363, 377, 398, 477, and 766, giving an average of 356 square inches excoriated or vesicated; and I may vouch for the data as free from exaggeration, and as rather on the contrary. Of these, the men now remaining under treatment showed 198, 355, 363, 398, and 477.

All these cases have two points in common, viz., the severity of the scald of the face and head, and sloughing spots of skin on the arms, in which indolent ulcers formed, leaving delicate cuticle that abrades and vesicates from slight causes.

The first (198) indicates the lowered chances of age, this man being the oldest of those injured, and fifty-three years old. He has had a heavy struggle in the febrile reaction, and healing has been retarded by indolent granulations. The figures 355 belong to the case alluded to in full, as that which had evaded the very worst forms of danger.

The highest amount, 766 square inches, is altogether exceptional, and it is inconceivable that he would have survived the primary shock and passed through the suppurative stage, had that extent of surface actually secreted pus. The scalded portion represented very nearly one-third of his superficies (which may be computed at 2,300 or 2,400 square inches), highly endowed with nerves and capillaries, and having a secreting apparatus of about 1,000 sweat-glands to the square inch. It is hard to realise what febrile reaction and what a depth of early prostration would have been consequent on suppurative inflammation of 750 square inches of such a tissue. I think we may set aside the question as one not within the scope of human endurance, not even under confluent small-pox, in which the purulent secretion is not prolonged as in the healing of a deep scald or burn. How are we, then, to account for his escape? The safest view is, that the injury to a great extent was only of the first degree—simple vesication that cicatrised without re-

removal of the epidermis—which is borne out by the first record of his being scalded all over the head, neck, and limbs in light vesications, and that so early as the end of the third week he was healed except in a few spots, after which he was detained only for nervous debility, that rendered him incapable of further service.

The history of this case has its points of almost tragical interest from his being one of a pair who, out of thirty-four, escaped with life from the immediate scene of the casualty. When the explosion occurred in the after stoke-hole he was at work in the fore stoke-hole, where he was knocked down by the force of the steam, and, as he states, his clothing was blown from his limbs. In this forlorn state he crept into a coal-bunker, when he was discovered insensible. The question of viability as affected by the amount of injury to the skin, and also that of the reparative power of skin as dependent on the depth of its injury down from the cuticular surface, are not unworthy of more precise observation. I would submit an opinion that in those who had not power to rally from the primary shock, as well as in those scalded to death in the stoke-hole, the viability was destroyed by the amount of violence done to the respiratory track, as well as over a large amount of sensitive nervous tissue, by which life was at once compromised beyond the recuperative power of the nervous centres; while, in the twelve who succumbed later, death was the consequence of the inability of the reparative forces to cause the restoration of the extent of tissue injured, dependent on its depth more than on its actual superficial extent. This conveys to my mind a sufficient explanation of the greater mortality from the sequences of gunpowder explosions than from scalds, within that degree in which viability is not at once annihilated. The amount of injury to the surface not inconsistent with viability is, in my opinion, approximately defined by the mean value of the measurements now recorded, so that I would view the removal of 350 inches of cuticle from an adult by scalding, whether by steam or by boiling water, and less in the latter case, as placing life in the greatest jeopardy, through inability of the systemic forces to sustain the impress of acute suppuration over so wide an extent, or to withstand the inflammatory sequences that arise in internal organs during the processes of external repair by prolonged suppuration and cicatrization.

In comparing results under my own observation, I am disposed to infer that, from the greater depth of gunpowder explosion burns, 250 square inches are on an average as fatal as 350 square inches of scalded surface, in which larger patches will not necessarily suppurate, but will heal without suppuration when the vesications are not torn off.

The treatment pursued in this casualty can only be spoken of generally in its constitutional and local aspects. Of the former, it may be said that, until decided signs of rallying were shown, stimulants with sago and beef-tea were liberally administered, and anodynes of opium and chloral-hydrate were given to relieve pain, and chloric ether or chloroform to allay any irritability of stomach, and the catheter was introduced whenever there was any urinary distress.

After rallying, beef-tea and animal food were given under appropriate circumstances during the night as well as the day. Milk was also freely poured in as a drink, mixed with lime-water where irritability of stomach had not subsided.

In all cases where no alvine evacuations had taken place on the third day, recourse was had to saline laxatives, with senna infusion, at intervals whenever called for. The disposition to constipation existed in all cases, so long as they progressed favourably; and, in fact, this disposition was observed throughout to be the most auspicious of indications, as a liberal diet of animal food was then always well borne, and in all such cases the healing processes went on rapidly. In the treatment of internal congestions and inflammatory reactions, general therapeutic indications were followed. In those of the air-passages, there was a very favourable course in the primary congestive stage; and pneumonic symptoms were developed in the secondary stage in only two instances, one of which died.

The meningitic symptoms scarcely admitted any treatment of a special character; nevertheless, two cases occurred in which ultimate recovery took place—there being besides several cases in which delirium was present.

Gastro-enteric disturbance often led to most unfavourable prognosis, but it subsided more frequently than the meningitic complications, in proportion as suppuration went on uninterruptedly; recurring in a few instances at a later stage, but not even then with fatal consequences except in one instance where coffee-ground vomiting occurred, perhaps from gastric ulceration.

The renal disturbance generally disappeared under a few doses of alkalis, with nitric ether; but suspicions were entertained that this complication may have depended on the too free use of carbolic acid in the dressings.

Weakness and prostration were in many cases extreme, and the greatest precautions had to be taken against syncope; but, notwithstanding this, one sudden death occurred from that cause. Exhausting dressings were, as a rule, postponed until after the patient had had some nourishment, and a slight stimulant administered immediately before their being changed. In the treatment of these cases, the habits of discipline of the sufferers were conducive to their recovery—inasmuch as the persuasions of officers rarely failed to secure the concurrence of the patients in carrying out whatever treatment was thought best for them. The local treatment was by oil and lime-water on cotton wadding, on every part, to the fourth and fifth days, and to a later period, in the majority of cases, on the limbs. Where suppuration commenced on the face, head, and neck, and the upper part of the chest, this being found inconvenient and dirty, causing distress to the patients, the moist dressing was changed for dry, cotton-wadding was abandoned, the parts were washed with carbolic oil, and then dusted, from a common flour-dredger, with a powder consisting of one part of oxide of zinc, one of carbonate of magnesia, and two of powdered starch, sifted on wherever moisture appeared, care being taken to keep the facial orifices free. By this means a firm incrustation was formed as a mask to the features, which remained intact, excluding the atmosphere. Under its protection, the process of scabbing, by which nature heals most of the wounds and sores of the lower animals, and of man himself in an uncivilised state, went on most favourably, so that, on the detachment of the crusts, the parts were found to have healed, which they did in the neck, face, and head very rapidly, except as regards the ears, the pinna, probably from the restlessness of the patients, gave trouble in many cases, and in some was the seat of abscess.

The results are that only in one case is there any permanent indicated cicatrix on the face producing deformity, and that in the parts where the mode of treatment could not be well applied. The advantages of this plan of treatment were first seen by me among the blacks in the Island of Mauritius, who, being employed in sugar-boiling, often meet with very severe scalds by superheated syrupy fluid. The material I saw used by them was nothing but pulverised calcined sea-shells, dusted on wherever moisture oozed out through cracks in the crust, which remained on until scabbing had taken place, not only excluding the atmosphere, but preventing the deposit of larvæ by flies, often a severe embarrassment in treating wounds in tropical climates.

I think so favourably of this treatment in the prevention of unsightly scars as to lead me to suggest its applicability in confluent small-pox, at least to the parts usually exposed. It was also used to a minor degree in some of the sores on the limbs, more especially of the hands and forearms, in some of which the scalds were so severe, that the cuticle, and in one the nails with it, came off in the form of gloves; and it is satisfactory to know that, although attenuated fingers and very thin cuticle will affect the sufferers for a time, yet there are no cases of contracted tendons to be recorded.

I mention this as an efficacious mode of excluding atmospheric air, and not as any new principle of treatment. In fact, it is but one of the numerous means to the same end which have been kindly suggested from many sources, among which I may enumerate immersion in a bath of olive-oil, covering the scalded surfaces with various paints and varnishes, dressings of many unguents, raw cream, and red currant jelly: all being the suggestions of the kindest desire to relieve suffering, although frequently emanating from a too limited experience. All I venture to claim for this is simplicity and readiness of application.

The treatment by oil and lime-water was disused generally before the tenth day, and, where the above was not employed, it was substituted by olive-oil with a twentieth proportion of carbolic acid, which was applied on lint under oiled silk, with Lister's gauze as a bandage, and this was very successful also, not, however, free from the suspicion I have already referred to, of its injuriously irritating the renal organs. In dealing with numerous cases with such extensive suppuration not free from superficial sloughs, there is an impossibility of maintaining a pure state of the atmosphere. Almost every deodorant was tried by sprinkling the floors with solutions delivered from the roses of watering pots, and by whitewashing them with suspended solids; but the plan found to be most efficacious was that proposed by Dr. Goolden: the imperceptible disengagement of chlorine from a mixed solution of nitrate of lead and common salt, sprinkled on the floors and spread on sheets hanging from screens placed near the beds from which offensive odours emanated.

In conclusion, I would add that very much has been due to the efforts by careful personal attention of the surgical staff under the guidance and responsibility of Deputy Inspector-General Loney, for by them the duties, however humble, if tending to the welfare of the sufferers, have been performed in a zealous spirit.