SOME OBSERVATIONS ON BURNS DUE TO EXPLOSION.

BY MAJOR C. B. C. ANDERSON,
Royal Army Medical Corps.

AND

CAPTAIN J. P. DOUGLAS,
Royal Army Medical Corps.

The following account has been written as a result of our experience in connection with the casualties sustained in H.M.S. “Hunter” and the German battleship “Deutschland,” with a view to making some assessment of the value and results of the various forms of treatment. The experience was an unusual one, and is of some importance, especially from the point of view of the Medical Services under war conditions.

H.M.S. “Hunter” struck a mine near Almeria during the afternoon of May 13, 1937, sustaining a large number of casualties. Some of these were taken on board the Spanish battleship “Jaime I,” where they received first-aid treatment within a few hours. The remainder were landed at Almeria and received treatment in the Spanish Military Hospital there. H.M. Hospital Ship “Maine” was despatched to Almeria to collect these casualties, and transfer them to the Military Hospital, Gibraltar, where they were admitted on May 15, 1937, forty-eight hours after the accident had occurred.

A total of twenty cases was admitted from H.M.S. “Hunter,” suffering mostly from burns of varying degrees and extent, associated with oil-fuel intoxication, fractures and other injuries.

During the evening of May 29, 1937, the German battleship “Deutschland” was struck by two aeroplane bombs while lying at anchor at Ibiza. One of these bombs penetrated two decks in the fore part of the ship, and exploded in the canteen, which at the moment was crowded with ratings. The other bomb exploded on the deck without doing so much damage. The result of this bombing attack was roughly one hundred casualties, most of which occurred in the confined space between decks. Twenty-three men were killed outright, and the eventual death roll amounted to thirty-one. The remainder sustained serious burns, complicated in many cases by fractures and wounds from bomb splinters, etc.

The “Deutschland” arrived in Gibraltar at 6 p.m. on May 30, 1937, twenty-four hours after the bombing, and immediately transferred thirty seriously wounded cases to the Military Hospital.

The following morning a further twenty-five cases were admitted, making a total of fifty-five German cases in all.

In both these incidents, the outstanding feature of the injuries sustained was the high percentage of burns. Of the total of seventy-five cases admitted from the two ships, there were only nineteen in which burns did not constitute the main injury.
C. B. C. Anderson and J. P. Douglas

It has not been possible to ascertain the actual causes of the burns in either case, but they would appear to be due in part to the flash of the explosion and in part to the subsequent fire. Incidentally it is known that the aeroplane bombs were not of the incendiary type.

It seems, reasonable, therefore, to suppose that similar incidents in the future will have similar results, and large numbers of burn casualties are to be expected.

The problem of dealing with a large number of such casualties under active service conditions on sea or land needs serious consideration.

In the case of H.M.S. "Hunter," forty-eight hours, and in the case of the "Deutschland," twenty-four hours had elapsed between the time of explosion and admission to hospital. This time factor is of considerable importance when one realizes that under ordinary conditions a burn case when seen at once is sterile, and that within twelve hours the Streptococcus haemolyticus can be grown in 80 per cent of cases [1] and moreover, it would seem reasonable to suppose that burns caused by explosions are likely to be primarily infected.

In both sets of casualties, in the majority of cases, shock was a marked feature on admission, and most of the burns could be classified as very extensive.

The following table, compiled according to the method of Berkow [2] shows the percentage of the skin area involved:

<table>
<thead>
<tr>
<th>Percentage of skin area involved</th>
<th>Percentage of cases</th>
<th>9 per cent of total cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10 per cent</td>
<td>9 per cent to 20 per cent</td>
<td>24</td>
</tr>
<tr>
<td>20 &quot; &quot; 30 &quot; &quot; 40 &quot; &quot; 50 &quot; &quot;</td>
<td>Over 50 per cent</td>
<td>10</td>
</tr>
</tbody>
</table>

Types of Dressing which had been used prior to admission.

(1) Tannic acid.
(2) Picric acid.
(3) Bismuth bandages (wismuthbrandbinde).
(4) Lanoline and cod-liver oil ointment.
(5) No dressings.

Treatment for shock had been carried out along routine lines, e.g. with morphia, cardiazol, coramine, fluids and warmth. As we have already noted, many cases arrived in a condition of shock with commencing toxæmia, which had no doubt been aggravated by the movement of cases during transport, and the cramped conditions in the ships.

(1) Tannic acid had been used only in the "Hunter" cases in the form of gauze compresses soaked in a 5 per cent solution. In a few instances blisters had been removed, but in most cases no complete cleansing or débridement had been attempted. No anaesthetics had been given for
Some Observations on Burns due to Explosion

dressings. These tannic acid applications had produced a good coagulum, but patients still had severe discomfort and pain, especially in the region of joints. Splinting of limbs might have relieved this to some extent, but it was impracticable owing to the extensive nature of the burns. Pus had already formed in many cases beneath the coagulum, and evidence of septic absorption and toxæmia was present.

(2) Picric Acid.—Only two cases had been dressed with picric acid. Both had extensive burns and were very ill on admission.

(3) Bismuth Dress (Wismuthbrandbinde).—Nearly all the German cases had been primarily dressed with these bandages which had been applied directly to the burnt surface. These were bandages impregnated with bismuth nitrate, zinc oxide and talcum, and according to the maker's instructions are applied without snipping of blisters or other interference. These dressings had become hard and tight, and much resembled a plaster-of-Paris bandage. Serum had soaked through in many places, and they were already smelling badly. All the patients complained of acute discomfort and begged to have the dressings removed.

(4) Lanoline and Cod-liver Oil.—This dressing had been used in only a few cases, and it did appear to give more comfort than did the bismuth dressing.

(5) No Dressing.—Some of the slighter cases had not been dressed at all. These were also septic.

TREATMENT ON ADMISSION.

(A) Cases from H.M.S. "Hunter."

All the burn cases had been dressed with tannic acid, except for two which had been dressed with picric acid. On admission, routine treatment for shock was instituted. This included morphia, fluids and glucose, and warmth. All were able to take and retain fluids by the mouth, and a minimum of one pint per hour was given. Elimination was effected by the use of magnesium sulphate.

Areas which showed a good tannic coagulum were left untouched, but in the areas which had not been treated, blisters and dead tissue were removed, and 10 per cent. tannic acid compresses applied.

The original tannic acid therapy had been done mainly without local débridement. Pus was already in evidence under the coagulated areas in most cases. Patients had pyrexia and complained of pain and discomfort, especially over the joints. The result was that in every case, the tannic coagulum had to be removed piecemeal to allow of the escape of pus, and to counteract the increasing toxæmia.

Many of these cases had face burns which had not been treated. These were dressed with plain sterile vaseline applied on a lint mask, and the patients appeared to experience much relief thereby.

Eyes showed conjunctivitis with purulent discharge, and required hourly
C. B. C. Anderson and J. P. Douglas

boric lavage followed by weak protargol drops, which rapidly cleared up this condition.

A striking feature of these face burns was the rapidity with which they healed, as compared with burns in other parts of the body.

Tannafax was tried in some of the previously untreated areas, but was not satisfactory. As the tannic coagulum was removed of necessity, leaving a raw septic area, it was considered that the kindest dressing to use would be a bland, easily changeable one. For this reason we employed 10 per cent eucalyptus in sterile vaseline, spread on sterile lint, and applied after gentle cleansing of the raw septic areas with weak dettol or equal parts of saline and eusol. This dressing appeared to give the patient a maximum degree of comfort and did not need to be changed more often than once in seventy-two hours.

All the first dressings were done under morphia, and thereafter patients were given pot. bromide, 30 to 60 gr. daily.

The result of these efforts was that in nearly every case the toxæmia had been overcome within four days. Routine examination of urine showed the presence of albumin in four cases, but this disappeared within a few days of admission. Of the two cases from H.M.S. "Hunter" which had been treated with picric acid, one, which had a fractured femur in addition to burns, was dressed with vaseline and eucalyptus after removal of the picric acid, and made a good recovery. The other with very extensive burns, involving at least 50 per cent. of the body area, was cleaned up under gas and oxygen anaesthesia as it was found impossible to do so under morphia. He was treated with 10 per cent tannic acid compresses. In his case the toxæmia was not controlled, severe sepsis occurred and within a week all the tannic coagulum had to be gradually removed. Vaseline and eucalyptus dressings were substituted. Thereafter he made a rapid improvement. Later on, flavine and paraffin (1/1,000) dressings were used on areas with complete destruction of skin.

In most cases the burns were complicated by other injuries, such as concussion, fractures, etc., but no complications arising from burns occurred, except the sepsis and temporary albuminuria.

No deaths occurred in hospital.

(B) Cases from German Battleship "Deutschland."

The thirty cases admitted on May 30 were all gravely ill owing to the extensive nature of the burns, severity of shock and associated injuries, such as severe concussion, fractured skull, other fractures, both simple and compound, wounds due to bomb splinters, etc.

These cases were all placed in one ward as they arrived. The general appearance of this ward, full of severely injured German sailors, was a sight which is difficult to describe in words. A few motionless and obviously moribund men; others restless and semiconscious, plucking at
Some Observations on Burns due to Explosion

their dressings and moaning with pain; faces burnt, hair singed, eyelids closed by oedema, limbs and bodies swathed in bandages, and an all-pervading aroma of burnt flesh. The many difficulties were multiplied by the language problem, until voluntary interpreters arrived to help.

The moribund cases, three in number, were suffering from burns covering over 80 per cent of the body surface, in addition to signs and symptoms of fractured skull. All these three men died within seventy-two hours of admission. It was not possible to do anything for them, beyond routine treatment of symptoms. Intravenous transfusion was found to be quite impossible in every case in which it would have been of value, due to the fact that superficial veins were not available owing to the extent of the burns.

Shock treatment was instituted in every case from the time of admission.

The amount of individual nursing attention required was a marked feature of this period and threw a very heavy strain on the available staff. It has been pointed out by Peyton Barnes that every burn case should have a special nurse during the first forty-eight hours [3]. This is obviously the ideal to be aimed at, but where large numbers of cases have to be dealt with simultaneously, it is frankly impossible.

On May 31 (twelve hours after the first batch) a further twenty-five injured German sailors were admitted. These were suffering mainly from burns, but on the whole they were of a less serious nature. Nearly all the German cases had been primarily dressed in the "Deutschland" with bandages impregnated with bismuth nitrate, zinc oxide and talcum (Wismuthbrandbinde). According to the maker's instructions on these bandages, they had been applied without any interference to the burn. It was particularly noted that as the patient began to recover from shock he was restless and complained bitterly of pain and discomfort, which was apparently due to the fact that the bandages had "set" like plaster of Paris and had become tight and adherent to the burnt areas, except where serum had soaked through. The areas of leakage of serum were increasing rapidly and becoming septic and malodorous.

Owing to these facts and also to a fear of the possible toxic effects of bismuth applied to such large raw areas, it was considered advisable to remove these dressings. In some cases it was found possible to remove them and clean up the burns under morphia; but all the severer cases were dealt with under gas and oxygen anaesthesia, which was well tolerated. Under this anaesthetic it was possible to do a thorough débridement and dressing. The dressing chosen in all these cases was as before, vaseline and eucalyptus 10 per cent. Our reasons for this choice were as follows:—

(a) The burnt areas were infected, and we had already learnt from the "Hunter" cases that tannic acid applied under similar cases had been unsatisfactory.

(b) The time-consuming factor in such a large collection of cases
precluded the use of tannic acid from a practical point of view, and the situation which was presented to us was the treatment at one time of some fifty cases of seriously burnt men.

(c) We were already convinced that the most important factor in successful treatment was early débridement, and that thereafter a mildly antiseptic dressing which gave comfort to the patient, and was easily changed, was the best type to employ.

It must be remembered that these burns were due to explosion, and that owing to dirt being driven in they do not do well with tannic acid (McCurdy) [4].

The routine treatment instituted from the beginning included glucose and fluids by mouth, one pint every hour, morphia, alopon and omnopon as required, antitetanus serum 3,000 units in all cases, anti-gas gangrene serum in selected cases complicated by bomb wounds, and magnesium sulphate for elimination.

In some cases continuous rectal saline was given, but in no case was it found possible to make use of the intravenous drip method of fluid replacement, for reasons already stated.

When we compared the progress of the "Hunter" cases (tannic) with those from the "Deutschland" (bismuth), our experience definitely showed that the healing time was shorter and the amount of sepsis was less in the latter cases. On the other hand the general condition on admission of the "Hunter" cases was much better than that of the Germans, and this fact can probably be attributed to the efficient anti-shock treatment which was made available during their twenty-four hours in the Hospital Ship "Maine," rather than to the effect of the original tannic acid dressings. Their general condition on admission indeed was better than that of the Germans after the latter had been receiving anti-shock treatment for twenty-four hours in hospital. This fact merely emphasizes the need for early efficient shock treatment.

As already noted, all the cases were septic from the start; original dressings were done under morphia or gas-and-oxygen as required. Subsequent dressings were made easier by the exhibition of potassium bromide backed by morphia when necessary. After all septic tannic coagulum and bismuth dressings had been got rid of, the eucalyptus vaseline was applied on pieces of lint about one foot square, which was changed about every seventy-two hours. As sepsis died down and healing progressed, these dressings were left in situ for longer periods. As soon as areas became dry, the vaseline dressings were replaced by the application of lotio calamine. All patients were kept on an expectorant mixture, as well as bromide, on account of irritable cough.

Complications (which are referred to later) were treated as they arose. There were no deaths in the "Hunter" series. Five cases from the "Deutschland" died, as follows:—
Some Observations on Burns due to Explosion

1—Multiple burns and fractured skull
1—Multiple burns and fractured skull
1—Multiple burns and fractured skull
1—Multiple burns and bronchopneumonia
1—Multiple burns and bronchopneumonia

36 hours following injury
48 hours following injury
72 hours following injury
7 days following injury
12 days following injury

In all fatal cases the total area of body surface involved by burns exceeded 80 per cent.

The following table gives a comparison in the healing time observed in the two series of cases:

<table>
<thead>
<tr>
<th>Healing Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage skin area involved</td>
</tr>
<tr>
<td>Under 10 per cent</td>
</tr>
<tr>
<td>10 per cent to 30 per cent</td>
</tr>
<tr>
<td>30 per cent to 40 per cent</td>
</tr>
<tr>
<td>40 per cent to 50 per cent</td>
</tr>
</tbody>
</table>

The complications which we encountered correspond with those enumerated by other observers (Dunbar [1], Strauss [5] and Kuhn [6]), and may be divided into early and late.

**Early complications** were sepsis (in every case), bronchitis, bronchopneumonia, and albuminuria.

A remarkable feature was the early evidence of sepsis. It would appear that burns due to explosions are infected from the beginning.

Chest complications occurred in the form of bronchitis in all the more serious cases, nearly all of which had burns involving the thorax and abdomen. Two of the fatal cases with burns extending to over 80 per cent of the body area had frank bronchopneumonia.

Routine examination of urine was carried out from the first day in every case, and albumin was found to be present in nine cases. There was no case of true nephritis, and the albuminuria cleared up very rapidly, except in one case.

**Late complications** were otitis media, 12 cases; erysipelas, 2 cases; follicular tonsillitis and quinsy, 8 cases; furunculosis, 5 cases.

Otitis media ranked highest as a complication, but it must be noted that in every case it was directly consequent on a traumatic rupture of the membrana tympani due to the effects of explosion in a confined space. It is interesting to observe that no cases of rupture of the tympanic membrane or otitis media occurred amongst the men injured in H.M.S. "Hunter." No case of mastoiditis or associated ear complications occurred.

Tonsillitis occurred in eight cases and was probably of the nature of "hospital throat," as it occurred when the burns were in the healing stage and patients almost convalescent.

Five cases of multiple boils occurred in patients who had sustained extensive burns. The skin infection arose after epithelialisation of the burnt areas was complete. The condition was not very resistant to treatment, which consisted of staphylococcal antitoxin, colloidal manganese and dressings of glycerine and magnesium sulphate paste.
Two patients who had extensive burns of the face developed erysipelas after the face burns had healed. They were treated with polyvalent antistreptococcal serum and sulphonamide P, which appeared to have a dramatic effect in controlling the spread of infection.

The complications observed in our series of cases agree with those noted by other writers. We had no cases of tetanus (all our cases were given prophylactic injection of anti-tetanus serum), scarlet fever, or peptic ulcer.

**General Remarks.**

On perusal of recent literature on burns, it transpires that there is no consensus of opinion that tannic acid is the one and only specific treatment. Undoubtedly good results are obtained with tannic acid, but we feel that these satisfactory results will occur only when there is a minimum of primary infection of the burnt area, and after a thorough preparation of the affected tissue by surgical cleansing prior to application of the tannic acid. Moreover we are of opinion that in burns involving total destruction of the skin, tannic acid is liable to be unsatisfactory. It is generally agreed that prevention of sepsis is the ideal to aim at, and this is obviously the important factor in the treatment of these cases. Burns sustained as a result of explosions such as caused the casualties described here, must, we think, be more liable to be septic than those resulting from other causes. Our observations on the results of tannic acid treatment as used in these cases help to bear out this fact, and to show that tannic acid applied directly to a potentially infected burnt surface is not the ideal method.

In some of the cases from H.M.S. "Hunter," where débridement had been carried out over limited areas, the tannic acid results were satisfactory in respect of those areas, which incidentally were not deeper than the second degree.

In this series of cases it may be stated that no primary surgical cleansing had been done, and we found that no matter what type of dressing had been applied, they were all septic. It appears to us that the actual type of dressing chosen is of secondary importance compared with the necessity for early débridement.

It should be realized that under Service conditions, when large numbers of burn casualties occur, circumstances may delay their arrival in hospital for twenty-four hours or longer. We consider that this time factor must be taken into account in deciding for or against the use of tannic acid.

The first-aid treatment of a large number of burns (apart from treatment of shock) is therefore a problem which requires investigation. It is worthy of note in this connexion that in pre-Listerian days, when the routine treatment of burns consisted of cotton-wool bandages (dry dressings), the results obtained showed a mortality as low as that claimed for tannic acid nowadays, and that the mortality from other methods of treatment was much higher (Dunbar [1]).
Some Observations on Burns due to Explosion

It has also been pointed out that explosive (infected) burns are unsuitable for tannic treatment (McCurdy [4]).

In view of these observations we offer as a suggestion the first-aid treatment of burns by dry dressings, which has the advantage of preventing extraneous infection, leaving the injured tissue alone and presenting for débridement a burn which has not been covered with chemical dressings or oily substances.

Amongst the types of first-aid dressing used in our series of cases, the German bismuth bandage most nearly approached our suggested dry dressing, but was not by any means satisfactory.

As regards treatment after reception in hospital, the literature seems to be mainly concerned with suggestions regarding numerous types of dressings, of which none has been found to be universally satisfactory. Perhaps not enough emphasis had been laid on the necessity for early surgical interference in the form of débridement.

We do not presume to suggest that the tannic acid method is not an extremely valuable one, but under Service conditions with infected burns and the almost inevitable delay in cases reaching centres where proper surgical débridement can be carried out, it cannot always be the method of choice.

Owing to the factors of sepsis, delay, and difficulty in its application to large numbers of casualties, tannic acid is not, in our opinion, the solution to this problem.

In our experience, gas and oxygen anaesthesia has proved to be an invaluable adjunct to treatment.

We would like to point out that the observations in this series of cases were of a practical nature entirely.

Although the dressing which we adopted (namely vaseline and eucalyptus ointment) has been largely abandoned as unscientific, and is stated to cause excessive scarring, increased sepsis, and long hospitalization (Bettman [7]), its extreme ease of application in dealing with large numbers of cases, and the comfort experienced by the patients, commended it, and we are satisfied with the results it produced.

The conclusions which we arrived at are derived from experience of the results of explosions on board warships.

Whether the same difficulties will be met with on land is problematical, though one must expect large numbers of burn casualties when incendiary aeroplane bombs are used.

The very important factor of delay in reaching hospital should be more easily overcome on land. We visualize the necessity for the organization of special departments in hospitals for the treatment of burns, on the lines of those used for fractured femurs, gunshot wounds of the abdomen and thorax, etc., during the Great War. There does not appear to be a completely satisfactory method of first-aid dressing which is suitable for use on active service. We would like to re-assert that, in our opinion, complete débridement is an essential preliminary to any form of subsequent dressing.
In conclusion we wish to record our thanks to Lieutenant-Colonel J. T. Simson, R.A.M.C., Officer Commanding, Military Hospital, Gibraltar, for permission to send these notes for publication.

REFERENCES.

[1] DUNBAR, JOHN, M.B., Ch.B. "Review of the Burn Cases Treated in the Glasgow Royal Infirmary during the Past Hundred Years (1833-1933)."

[2] Berkow's method of estimating percentage of skin area:

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and neck</td>
<td>6 per cent</td>
</tr>
<tr>
<td>Trunk—total</td>
<td>38 per cent</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>18 per cent</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>38 per cent</td>
</tr>
</tbody>
</table>

Upper extremity:
- Anterior surface
- Posterior surface

Lower extremity:
- Hands 1/4 of total
- Arms 1/2 of total
- Feet 1/4 of total
- Legs 1/2 of total
- Thighs 1/2 of total


