WAR WOUNDS AND AIR RAID CASUALTIES

The following article is a supplement to the series of lectures on war wounds and air raid casualties printed in these columns*

CHEMICAL WARFARE AND THE DOCTOR—II

BY

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Technique of Attack by "Gas"

Service medical officers should study *Gas*, by Major-General C. H. Foulkes (1936), where a full account is given of the various methods of employing chemical warfare in the field. These include the use of drift gas from cylinders, mists and mixtures from projectors fixed electrically, Liven's drums, Stokes's motor bombs, "M" generators (thermo-generators on the smoke-candle principle, for generating clouds of the arsenic mists), sprays from aeroplanes, as well as various types of gas shell fired by the artillery.

Gas attacks on the civil population will be made from the air. Mitchener and Cowell, in their *Medical Organization in Air Raids*, 1939, quote General Golovine, who gives statistics showing that the complete overwhelming of a capital city by gas is impossible. Repeated attacks may be made by small formations of three to nine machines, or larger numbers—twenty-seven to thirty-six. As the air defence of this country becomes stronger this menace is proportionately diminishing. It is possible for gas to be sprayed by a low-flying machine or clouds to be laid at a height. The spray from the former may be seen coming from the machine and falls like rain; from the latter the mist may arrive from some distance, its presence being only appreciated from its effects.

For the success of a gas attack weather conditions must be favourable. Clear, mild, still nights, with an absence of mist or rain, afford the best chances for success, both for non-persistent and persistent gases. Heavy rain and a high wind will minimize the toxic effects. Clear sunny days cause rapid dissipation of the non-persistent gases; a raised ground temperature increases the volatilization of the persistent gases and gives rise to a high local concentration.

Counteraction of Gas Attacks

The object of any gas raids undertaken against the civil population will be to inspire panic, confusion, and terror, with such a lowering of national morale that peace will be insisted on at any price. The air menace may be averted in four ways: (1) Reliance on agreements, pacts, and action by such bodies as the League of Nations; (2) active defence, by the provision of a powerful Air Force; (3) passive defence—anti-aircraft units, batteries, searchlights, etc.; (4) air raid precautions. No. 1 needs no comment. The second and third are becoming stronger every day in this country. With regard to air raid precautions the Government's plans are gradually being perfected. But further organization and liaison between various departments, provision and training of more personnel, and repeated exercises and practice are required

to render this arm of defence as efficient as the second and third.

The doctor not a member of the medical branch of the fighting forces will help in A.R.P. work. It has already been realized by the Home Office, Ministry of Health, and the British Medical Association what an important part the medical practitioner can play, whether surgeon, physician, or family doctor. He can help not only in preserving the calmness of the public, and preventing the effects of chemical warfare by correct prophylaxis, but also, by his knowledge of both first aid and treatment of gas, save life and hasten recovery.

It is essential that the whole nation be made gas-conscious. This applies not only to members of the A.R.P. services, including all medical personnel, but also to all members of the public. Refugee and evacuation camps may be attacked by gas as well as the densely packed centres of the cities. Further instruction is needed, and a stricter gas discipline, with frequent respirator practice, is urged. Details of protection by sealed rooms, protective clothing of different types, and the wearing of one of the three types of respirator are to be found in the Home Office Manuals. Dressing stations, first-aid posts, and operating theatres in vulnerable areas should not only be splinter-proofed but gas-proofed.

All doctors are advised to practise wearing an anti-gas respirator. Familiarity with the general service type will ensure the comfortable wearing of the civilian duty and civilian anti-gas types. Details may be obtained from the books, but actual frequent practice is essential. The doctor should be able to get his respirator on in ten seconds or less and wear it for at least one hour, even with spectacles on, without the eyepieces dimming or any loss of technical efficiency. One can lecture for forty minutes on the respirator alone without repeating oneself.

It is quite feasible to perform surgical operations wearing a general service respirator, even when the surgeon has to wear glasses. Wearing the haversack at the back instead of the front of the chest ensures a sufficient supply of air when wearing sterile clothing. Theatre sisters should be taught to wear either a civilian duty respirator or, better, the G.S. pattern slung at the back, in which position it will not get in the way when stooping over instruments.

Prompt diagnosis is the first essential. It must be at once ascertained whether the "casualty" has really been exposed to gas, and, secondly, if so, the nature of the gas must be determined. A record of each case should be made and preserved on the special form prepared by the Ministry of Health. Information on the following points can generally be given by the patient or a friend: (1) condition of exposure—that is, air, spray, exposure to contaminated clothing, etc.; (2) nature of the smell; (3) duration of exposure; (4) immediate effects; (5) late symptoms; (6) when did the exposure occur?

War Gases and their Effects: Group I—Lacrimators

The liquid lacrimators may be sprayed or dropped by bombs from the air. C.A.P. requires heat. The presence of one of these substances causes an immediate irritation of the sensory-nerve endings of the conjunctiva and cornea. Profuse watering of the eyes and spasm of the

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lids temporarily blind the victim. Further concentrations may cause mild respiratory discomfort. No permanent lesions are produced, and when removed from the contaminated atmosphere all symptoms disappear in one to two hours. C.A.P. may irritate and redden the skin. An account of one case was personally communicated to me by Dr. A. C. Coleman. A young lady stayed twenty minutes in a C.A.P. chamber. A few hours later she developed severe urticaria, which fortunately immediately responded to injections of adrenaline. Perfect protection is afforded by the respirator.

First Aid.—Diagnose on the immediate lacrimation and blepharospasm. Apply respirator and remove to clear atmosphere. Irrigate the eyes with warm saline (very seldom necessary). Reassure the patient; he will recover within twelve hours. Do not send him to hospital. Established cases do not require any special treatment.

Group II—Sternutators

These are the arsenic compounds, and require heat or detonation to form them into a fine mist of minute particles. This gas cloud may be almost invisible. There is a latent period and some minutes elapse before symptoms appear. Thus symptoms may arise or become worse after putting on a respirator; an untrained person tends to take off his respirator, thinking he is no longer being protected. This is in direct contrast to Group I, where symptoms are immediately relieved by putting on the respirator. The symptoms are those of severe pain in the nose and sinuses, with repeated sneezing, burning of the throat, sore eyes, aching gums, and possibly nausea or vomiting. Mental distress may be a prominent feature, and inability to think or concentrate is generally experienced. Although alarming, the symptoms generally disappear in an hour. No permanent damage is done, and these cases need not be admitted to hospital. Modern respirators contain cellulose pads to filter off the arsenic smokes.

First Aid.—Diagnose on symptoms and the history, and do not be deceived by the severity of the symptoms and the anxiety of the patient. Apply respirator; remove to clear atmosphere. Reassure the patient; recovery will occur in an hour or two. Do not send to hospital. If the pain in the sinuses is very severe, light chloroform inhalation will give relief. For a painful nose or throat 5 per cent. sodium bicarbonate solution may be used as a wash or gargle.

Group III : Vesicants

MUSTARD

Mustard is a very insidious poison. It may escape immediate detection and does not produce symptoms for some hours. Repeated exposure may lead to hypersensitivity. Lesions may result from spray from the air, splashes from bursting bombs, or slow vaporization from contaminated buildings, ground, clothing, etc. On the skin no immediate sensory effect is appreciated. The poison penetrates clothing and enters the skin deeply and quickly, producing an erythema only after some hours. Local oedema and capillary stasis follow; later the erythema deepens in colour, a pale centre appears, and a vesicle containing yellow serum is formed. This does not contain mustard. Intense itching is usually noted, and the moist parts of the body are chiefly affected. Secondary infection is liable to occur and healing is slow. The healed scars may be pigmented for a time.

Exposure to vapour only may produce extensive effects on the eyes, temporarily blinding the subject within a few

hours after exposure. Contamination by droplets of splash or spray is more serious, and may lead to permanent blindness from corneal scarring. Symptoms may begin within half an hour, and soon the eyelids become painful and swollen. Intense oedema of the lids follows, together with swelling and reddening of the conjunctiva. Corneal opacities appear, the ocular conjunctiva may ulcerate, the tension is increased, and a profuse muco-purulent discharge takes place. Photophobia and spasm of the lids may be intense.

If the respirator is not put on soon enough then the nose, larynx, trachea, or lungs may be affected. Epigastric pain and vomiting may occur from the swallowed saliva. The effects, however, do not persist. Renal complications have been noted in fatal cases. Local oedema of the penis may cause retention of urine.

Mustard Vapour.—If in from twelve to twenty-four hours after exposure to a dilute mustard vapour the eyes become red, the voice is husky, and the skin erythematous a positive diagnosis may be made. Prevention consists in wearing protective clothing, applying the respirator, and washing in soap and water or rubbing in bleach ointment for one minute. First aid consists in changing all clothing, complete bathing of the body, and repeated eye lavage. This suffices for mild cases. Note that speed is essential: cleansing must be undertaken within two minutes for liquid and fifteen minutes for vapour, otherwise burns will result. The same applies to Lewisite, except that the poison is appreciated at once and the characteristic smell is always found.

Liquid Mustard.—Yellow detector disks reveal splashes of mustard as bright red spots (red for danger). If clothing is found contaminated it must be removed as soon as possible and the patient treated as mentioned above. If the eyes are contaminated warm saline irrigation must be carried out immediately and be maintained at hourly intervals. In the open, water from a water-bottle should be poured into the eyes, followed by a drop of liquid paraffin.

LEWISITE

Lewisite resembles mustard in its action, but is less insidious. It is early detected by its odour and has a shorter latent period, both in the eye and on the skin. In extensive burns acute arsenical poisoning may result. On the skin an immediate stinging sensation follows the application of liquid lewisite. Erythema occurs within thirty minutes; vesication, too, is early, and is complete within twelve hours. Clinically the effects of lewisite and mustard can now be sharply distinguished. The lewisite blister is clearly defined: it covers the whole erythematous area and is filled with a cloudy fluid containing leucocytes and arsenic. The mustard blister has a surround of erythema and is full of a clear yellow fluid, but contains no mustard. On dry clothing lewisite is less effective than mustard, and when the clothing is wet the lewisite loses much of its effectiveness owing to rapid hydrolysis. The fine spray of lewisite is even more dangerous to the eyes than that of mustard. Immediate irritant symptoms follow. In fifteen minutes an acute conjunctivitis occurs, oedema of the eyelids, pain, and photophobia rapidly supervene, and in three to nine hours the whole painful picture is produced, an effect which is only seen with mustard at the end of twenty-four hours. The ultimate prognosis is graver also.

Since the presence of lewisite is readily appreciated the respirator is usually put on early and affords protection. As in the arsenic smokes, the symptoms of irritation may appear even after the application of the respirator. In

the absence of a respirator nasopharyngitis follows, and bronchitis may be established in twenty-four hours, which may lead to bronchopneumonia and death.

TREATMENT OF VESICANTS

Skin.—So long as droplets of mustard are visible on the skin bleach ointment will lessen the severity of the burn. This is made by mixing equal weights of "super-tropical" bleaching powder and white petroleum jelly. It is stable in ordinary climates. If the contamination is extensive, bleach paste is easier to apply. Bleach paste consists of one part (by volume) of "supertropical" bleaching powder mixed with two parts of water. The affected area is swabbed for several minutes until no further odour remains. Any of the following solvents may be used: petrol, methylated spirit, paraffin, etc. Care must be taken to avoid fire; the contaminated swabs, after careful handling, must be burned. Cleansing with soap and water removes the surface "gas" and will prevent burns if carried out within five minutes. The dresser should wear gloves. This method should not be attempted if erythema has begun, but swabbing should be employed. If there is a massive contamination, the application of bleach ointment is advisable. In the case of established lesions, erythema, if mild, will clear up as in sunburn, leaving a slight pigmentation and desquamation. Tannic acid jelly or solution should be useful. With vesications the aim will be to prevent secondary infection. Mustard burns should be treated on the surgical principles outlined by Mitchiner and others. Thorough cleansing—under an anaesthetic if necessary—is followed by the application of a tannic acid compress—layers of lint or gauze soaked in a 2½ per cent. solution of tannic acid, freshly made; this is left *in situ* for several weeks if desired.

Eyes.—As soon as the patient comes under medical care, and while he is being cleansed in the shower-baths, an opportunity is taken to irrigate the eyes with 2 per cent. sodium bicarbonate solution. If the eye is contaminated with liquid mustard do not wait for the onset of signs or symptoms, but continue the alkaline lavage as often and as long as possible. This treatment becomes difficult as the oedema and spasm of the lids increases. To relieve this apply 1 per cent. sterile atropine ointment twice a day (and in all cases where the cornea is damaged). Do not apply cocaine. Do not bandage the eyes—apply a light shade and instil liquid paraffin at frequent intervals. If the discharge becomes muco-purulent 2 per cent. argyrol twice a day is indicated. The treatment of corneal ulcers, with or without hypopyon, is best left to an ophthalmic expert. With vapour contamination only the prognosis is better and the patient may be immediately reassured. In mild cases irrigate every two hours with 2 per cent. sodium bicarbonate solution, instil liquid paraffin, and apply a shade or keep in a darkened room. In more severe cases treat as for liquid contamination.

The Respiratory Tract.—Rhinitis will respond to warm douches of 5 per cent. sodium bicarbonate solution. When there is laryngitis, rest the voice, keep in the fresh air, and give a paraffin spray or vapour inhalation. (Menthol, 10 grains, tinct. benzoin. 1 oz.; sig., 1 drachm to a pint of boiling water.) Some 2 per cent. of the mustard cases in the great war ended fatally. The majority of these deaths were from bronchopneumonia. To prevent this complication keep cases where the lungs are involved in special wards, warm and well ventilated. Isolate any case of secondary infection as it occurs. Menthol is useful in allaying coughing.

As pointed out in the *Medical Manual* already referred to, it is wise to send patients as soon as possible to a special convalescent centre. This will prevent the onset of "anxiety" neurosis and such conditions as functional photophobia and aphonia. Finally, doctors looking after civilian gas casualties should remember that gassing does not in itself cause a permanent state of ill-health. Undoubtedly many gassed patients will develop neurasthenia and apply for disability pensions. Properly handled, this state of affairs will not eventuate.

PROTECTIVE MEASURES

(1) There is the standard suit fully described in the Home Office manuals. None of the recent official publications, however, mentions the important work of Major Crowden of the London School of Tropical Medicine and Hygiene. Writing in the *R.A.M.C. Journal*, this officer describes a method whereby a man can continue to perform hard manual work in full protective clothing for several hours without ill effects. A light drill shirt is put on over the waterproof and kept constantly wet with cold water. The loss of heat by evaporation keeps the wearer cool. (2) Several other types of clothing exist for troops in the field. (3) For first-aid services there are the following: (a) rescue and first-aid parties—a heavy standard suit; (b) ambulance drivers—long coat, gloves, gum-boots, curtain, and respirator or eye shield; (c) undressers—protective apron with sleeves, gum-boots, and respirator (generally civilian duty). The methods of decontaminating clothing and buildings, etc., are fully described in the various Home Office manuals.

Group IV—Lung Irritants

These gases may be discharged from air bombs or cylinders carried on low-flying aircraft. The gas is heavier than air and is carried down wind. Immediate application of the respirator gives complete protection, but speed is essential. A single breath of phosgene may be very dangerous.

Pathological Action.—All lung irritants act on the bronchial tubes and alveoli, causing acute pulmonary oedema. A lacrimatory effect is also produced. Chloropicrin is four times and phosgene ten times more toxic than chlorine. On post-mortem examination the chief changes are pulmonary oedema with disintegration of the alveoli. The blood becomes concentrated and tends to form thrombi. Pulmonary oedema may occur within two hours of the gassing. In the first twenty-four hours the lungs are found to be full of blood and are oedematous, with patches of emphysema alternating with collapsed areas. A pleural effusion may be present. After the second day the oedema begins to disappear, but a secondary infection leads to pneumonic patches and pleurisy. The haemoglobin may rise to 140 per cent. in the blood, and is associated with pulmonary or systemic thrombosis.

Clinical Types.—Two groups may be distinguished: the acute type with violent onset, and the acute type with insidious onset. When the onset is violent phosgene in heavy concentration and chlorine and chloropicrin will cause immediate symptoms. The patient coughs, catches his breath, and complains of a pain in his chest. The breathing becomes rapid and shallow; deep breathing brings on a painful cough. Retching and vomiting occur and the patient is knocked out. With the onset of oedema the breathing becomes rapid and shallow and the patient becomes blue, with distended veins. (See *An Atlas of Gas Poisoning*, H.M. Stationery Office, 1939.) In phos-

gene poisoning this blue phase may be passed over and quick collapse follow, with a rapid pulse and symptoms of toxic shock. Here the patient may die in two to three hours after exposure. This group of acute cases may be classified into (1) mild cases—flushed face, increased respiration rate, and cough; (2) severe cases—"blue" type, with a full pulse; (3) severe cases—"grey" type, with toxic shock. Type (1) soon recover; Type (2) do well if the pulse does not rise above 100; Type (3) do badly, and death results from circulatory failure or bronchopneumonia. In the group in which onset is delayed persons exposed to phosgene go on with their duties for a few hours and then suddenly collapse with a rapidly increasing pulmonary oedema, often fatal. Sir William Horrocks described to me how this delayed action was discovered in 1915. Some young pigs were exposed to a low concentration of phosgene and appeared none the worse. Next morning, however, they were all dead.

In the early stages very few physical signs are to be found. Later the percussion note may not be impaired, but the breath sounds become feeble, especially over the back, where fine rales appear. Blue cases, which respond to oxygen, may do well, and the pulmonary oedema is also over within four or five days. Grey cases with heart failure do badly. Bronchopneumonia often supervenes. In the great war 80 per cent. of lung-irritant deaths occurred within the first twenty-four hours.

Diagnosis.—There is a distinctive smell, and the history will help. Chlorine and chloropicrin produce urgent symptoms even in low concentrations. Relief is immediate on applying the respirator. Phosgene and diphosgene, however, even though smelt, can be breathed without coughing in low but lethal concentrations. Suspect casualties should be carefully questioned and examined. If it is certain the patient has been exposed to a lung irritant he should be kept at rest for twenty-four hours and watched. If the exposure has been short and there are no symptoms, he may be discharged after a further twenty-four hours.

First aid must be begun as soon as a positive diagnosis is made. The patient must be treated as a stretcher case, be kept warm and as quiet as possible, and be put on a light diet. Make preparations for giving oxygen and performing venesection if signs of lung injury supervene (dyspnoea, tachycardia, cyanosis, frothy expectoration, and concentration of the blood).

Treatment of Established Cases.—Suspect cases must be kept at rest and observed for twenty-four hours. If no symptoms have arisen in the next twenty-four hours they may be discharged. In the acute stages the treatment consists in rest, warmth, venesection, and oxygen. If the patient is tided over the first few days the oedema will absorb and recovery is possible. Treat all lung casualties as stretcher cases and after admission to hospital keep them quiet in bed. All contaminated clothing must be removed as soon as possible. As in the treatment of wound shock, it is most important to keep the patient warm. Venesection is carried out on the appearance of cyanosis: 15 to 20 oz. (400-600 c.cm.) are withdrawn by acupuncture. It is possible that further experience may show that subsequent introduction of normal saline intravenously may be beneficial. If the cyanosis deepens and pulmonary oedema increases, oxygen is initiated. Venesection is harmful to the grey cases. Oxygen may be required to be given continuously for some days. Nurses should be instructed in the use of an oxygen tent, closed or open pattern, nasal catheter, or Haldane's mask. An average of five litres a minute will be required

for each patient. In the great war it was found that no patient in whom a pink colour was obtained by the use of oxygen died from pulmonary oedema.

Expectoration may be encouraged by posture. The Tor table (Mitchiner and Cowell) provides a simple method of lowering the patient's head to allow the serous fluid to escape from the lungs. No drugs were found to be of value in the great war. If pneumonia supervenes, some of the new drugs may be tried; but no opportunity has yet arisen to test their efficiency under these conditions. In treatment of the convalescent the remarks made with regard to mustard will apply here also.

Group V—Paralysants

The diagnosis of this group presents no difficulties. **First Aid:** For both HCN and H₂S prolonged artificial respiration with administration of O₂ and CO₂ is indicated. In these cases some form of artificial respiration by apparatus, such as an "iron lung," Eve-Riley rocking stretcher, or the Tor tilter, may save life. Full details are to be found in the *Medical Manual of Chemical Warfare*.

Surgical Treatment of Gas Casualties

It will probably be found that the number of wounded and gassed cases will vary inversely—that is, there will be wounded only and no gas, or vice versa. In individual cases decisions must be made according to the circumstances. A man contaminated with mustard must be stripped and cleansed and reclothed before being admitted to the pre-operation ward and theatre. General anaesthesia may be inadvisable in the case of lung-irritant poisoning, but gas-and-oxygen preceded by menthol inhalation will probably be safe in mild cases. Operating theatres, as already noted, should be splinter-proof and gas-proof. If these precautions have not been taken the surgeon and all the members of his team should be prepared to work in respirators if necessary.

Concluding Remarks

Undoubtedly many gas casualties will arise among women and children. The children will require extra nurses, and will probably fare worse than adults. I saw infants with mustard burns in some of the villages near the line in France during the last war, but only in small numbers. They made constant demands on their mothers.

When gunpowder was introduced the men of the time said, "How terrible; cannot we go back to the humane bow and arrow?" The same has been said of chemical warfare. But with careful education, preparation, organization, discipline, and determination it will be easier to protect the people of this country against gas than against high-explosive or incendiary bombs.

A short bibliography is given below: for a very full list of authors (826) the reader is referred to Hanslian, vol. i, *Der Chemische Krieg*, 1937.

I wish to acknowledge my indebtedness especially to the most excellent *Medical Manual of Chemical Warfare*, 1939, which should be read by all doctors.

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