

# A Brief Consideration of Chemical Warfare

By H. CLYDE SLADE, '41

THE introduction of the use of gases in the war of 1914-1918 may be said to be an advance in military Science comparable to that represented by the substitution of guns for crossbows during the fourteenth century.

Gas warfare really started on the twenty-second of April, 1915, when the Germans set free chlorine which was carried by the wind over the Allied trenches. Since that day an enormous amount of research has been done with respect to the production and use of gases for this purpose.

The word gas as used here includes not only true gases such as chlorine, but also other materials whether liquid or solid which are used for the same purpose.

"Gases" are usually divided into two groups, (a) Persistent and (b) Non-persistent. The former group includes those materials that can lie about in liquid form, giving off vapour, while in the latter group are placed those which being volatile or in the form of smoke only infect the air, and are, therefore, entirely removed when the air is changed by the wind. The importance of this grouping lies in the fact that with a persistent gas it is, of course, necessary to remove or destroy any liquid that may remain on the ground, houses, clothes, etc., before we can be safe. However, it can only be roughly applied because the persistence of a gas varies greatly with the manner in which it is spread and with the weather.

War gases are often classified according to the effects they produce, into:

1. Lacrimators or Tear gases, those which affect the eyes only.
2. Sternutators (Latin, Sternutare—to sneeze) those which temporarily affect the nose and throat.
3. Lung Irritants (choking gases) those affecting the throat and lungs.
4. Vesicants (blister gases) those affecting the skin.
5. Paralyzants.
6. Other dangerous gases and fumes.

## Lacrimators.

These and the nasal irritants which are to be described next have certain general features in common.

- (1) Selective action—attacking only exposed sensory nerve endings or mucous membranes for example, those of the eye, nasopharynx and respiratory tract.
- (2) Effectiveness in extremely low concentrations.
- (3) These effects are immediate but temporary.

Examples of lacrimators are Chloracetophenone (C.A.P.), Ethyliods acetate (K. S. K.) and Bromo-benzyl-Cyanide (B. B. C.) The liquid lacrimators (B.B.C. and K.S.K.) may be sprayed or dropped by bombs from the air but C.A.P. a solid, requires heat. The presence of one of these substances causes a profuse watering of the eyes and some blepharospasm, temporarily blinding the victim. Stronger concentrations may cause some respiratory discomfort. However, under usual circumstances no permanent lesions result. C.A.P. may irritate and redden the skin, particularly of persons with moist skins who sweat much; in those who don't there is a possibility of the development of an obstinate allergic dermatitis if often exposed to the vapour.

*Treatment:* Immediately lacrimation and blepharospasm occurs, apply a respirator. Lavage of the eyes with normal saline is rarely necessary. Even after severe exposure all symptoms clear up within twelve hours.

### **Sternutators.**

These compounds for example, Diphenylchlorarsine (D.A.), Diphenylaminechlorarsine (D.M.) and Diphenylcyanoarsine (D.C.) are all arsenical compounds and are dispersed by heat or detonation into a fine mist or cloud which may be almost invisible. They share the general characteristics mentioned in the section on Lacrimators.

There is a latent period before symptoms appear and when they appear *after* the respirator has been on for a few minutes, there is danger that the victim will tear if off in the belief that he is not being protected.

The chief symptoms are severe pain in nose and sinuses, sneezing, burning in the throat, sore eyes, aching gums and possibly nausea and vomiting. There may be mental distress with inability to think or concentrate.

*Treatment:* Apply a respirator, if possible remove to a clear atmosphere, reassure the patient; and recovery with no permanent damage will occur. in an hour or two. With much pain in the sinuses, a few whiffs of chloroform are helpful and for a painful nose and throat, a gargle or spray of 5% Sod. Bicarb. solution is useful.

### **Lung Irritants.**

The chief members of this group are chlorine, phosgene, diphosgene and chloropicrin, the latter two being somewhat persistent owing to their comparatively high boiling points.

Owing to the relatively low tonicity of chlorine and chloropicrin, in comparison with that of phosgene, and also because of the ease with which their presence, even in low concentrations is advertised by their irritating action, it is likely that in the coming wars phosgene will be used in preference to either of the others.

All these lung irritants with the exception of chlorine may be discharged from any type of projectile in modern use—shell, bomb, (either aircraft or mortar) or from a Livens drum. The gas is heavier than air and is carried down wind. Immediate application for a respirator gives

complete protection, but speed is essential, as a single breath of phosgene may be very dangerous.

*Pathology.*

All lung irritants act on the smaller bronchial tubes and on the alveoli of the lungs. The great danger is the onset of pulmonary oedema; the rate of onset, and the degree of oedema, depending on the particular gas being used, its concentration, and to a lesser extent on the duration of exposure.

They are also effective lacrimators, particularly phosgene and diphosgene though in this respect they are far less powerful than the true lacrimators.

The relative toxicity varies, that of phosgene and diphosgene being about equal, while chloropicrin is four times and phosgene ten times more toxic than chlorine.

Post mortem examination shows chiefly pulmonary oedema and alveolar disintegration. The blood becomes concentrated and there is a tendency to thrombus formation. The pulmonary oedema may occur within two hours of the gassing. On the first day the lungs are found to be bloody and oedematous with occasional patches of emphysema. There is almost invariably a serous or even blood stained pleural effusion. After the second day the oedema begins to disappear but secondary infection gives rise to a patchy broncho pneumonia and pleurisy.

**Symptoms and signs of Lung irritant poisoning:**

The cases can be divided into two types:

(1) *Acute with violent onset.*

Typically seen after exposure to chlorine or chloropicrin, or even phosgene in an effective concentration. The victim coughs, catches his breath and complains of a sensation of constriction and pain in the chest. Breathing is rapid and shallow. Retching, vomiting, and a profound sense of fatigue often prostrate the patient. The rapid shallow breathing is a sign that oedema is present; and the patient becomes blue with distended veins. With phosgene poisoning the blue phase may be absent and we may get a quick collapse with rapid pulse and symptoms of shock. This type of victim may die in two or three days.

Apart from the fulminating cases this group of acute cases may be divided into three types.

- (1) mild cases with flushed faces, cough and increased respiratory rate,—these soon recover;
- (2) severe cases with blue cyanosis and a full pulse,—these cases usually do well if the pulse does not rise above 100;
- (3) severe cases with leaden grey cyanosis and toxic shock—these cases do badly and death occurs from circulatory failure or broncho pneumonia.

(2) *Acute with insidious onset.*

This type of case goes on with normal activity for a few hours and

suddenly collapse occurs with a rapidly increasing pulmonary oedema, often fatal.

*Physicals Signs*—very few in early cases, but later, though the percussion note may remain resonant even when pulmonary oedema is present, the breath sounds are diminished, especially over the back where fine rales may be heard.

With the onset of inflammatory complications and a rising temperature, the physical signs become those of pleurisy, bronchitis, or broncho pneumonia.

*Diagnosis*—the distinctive smell and history is of help. Phosgene and diphosgene though smelled, can be breathed without coughing in lethal concentration but chlorine and chloropicrin produce urgent symptoms in low concentration.

Victims obtain immediate relief on applying the respirator. Suspect cases should be kept at rest and observed for twenty-four hours; if there has been only short exposure and no symptoms, they may be discharged after a further twenty-four hours.

*Treatment:* For acute cases the treatment consists of rest, warmth, venesection and oxygen. If the patient is tided over the first few days, absorption of the oedematous fluid and recovery may occur.

*Rest*—All lung casualties are stretcher cases and on admission to hospital all contaminated clothing must be removed as soon as possible and the patient kept quiet in bed.

*Warmth*—Just as important as in the treatment of wound shock.

*Venesection*—On the appearance of cyanosis 400-600 cc.'s of blood are withdrawn from a vein, venesection should not be carried out on the "grey" cases.

*Oxygen* — is indicated if cyanosis deepens and pulmonary oedema increases. It may be required for some days and can be administered by means of an oxygen tent, nasal catheter or a Haldane mask.

*Expectoration* is encouraged by posture; lowering the patient's head allows serous fluid to escape from the lungs.

No drugs were of any avail in the last war, though at the present time some of the newer drugs may be used to good effect in the treatment of the complications due to secondary bacterial invasion.

#### *Convalescent Treatment.*

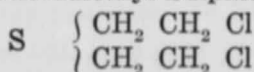
Cases should not be moved for purposes of convalescence until cyanosis and severe symptoms have disappeared.

In the case of minor casualties recovery is possible after a short rest, but those who have been severely cyanosed or who have had complicating broncho pneumonia require a very much prolonged convalescence. All except the more severe cases should be out of bed as early as possible. This practice is not contraindicated by mild bronchitis, or gastric disturbances which are usually only temporary, but cases with abnormally rapid or slow pulse should be rested for a longer time.

There should be instituted a period of carefully graduated exercises which must however, be applied to each patient with individual care. Exhaustion must be guarded against for fear that disordered action of the heart (D.A.H.) may develop and thus add months to the period of convalescence.

#### Vesicants or Blister Gases.

Of this group, mustard gas is the most important, its chemical name is B B Dichlorodiethyl Sulphide and its Structural Formula:



It is an oily liquid colourless when pure but brownish when impure, boiling at 271°C and has only a faint odor of garlic.

It is a very insidious poison, since it does not produce symptoms for some hours and may escape immediate detection. Lesions may result from spray from the air, splashes from bursting bombs, or slow vaporization from contaminated buildings, clothes, etc. The poison penetrates the clothes and skin and after some hours an erythema develops with local oedema and capillary stasis. Later the erythema deepens and a pale centre is formed which turns into a yellow vesicle containing yellow fluid. Intense itching is noted and the reaction occurs mostly on the moist parts of the body.

Exposure to the vapour may produce extensive effects only on the eyes, temporarily blinding the victim within a few hours after the exposure. Droplet or spray contamination is much more serious and may lead to permanent blindness from Corneal Scarring. Symptoms may begin within half an hour, the lids becoming swollen, painful and oedematous. Likewise the conjunctiva becomes swollen and reddened.

Corneal opacities or even ulceration with a profuse mucopurulent discharge may appear. Photophobia or spasm of the lids may be intense.

The respirator affords complete protection for the eyes and lungs, because the mustard gas vapour is easily caught in the charcoal by absorption. But, if the respiration is not put on soon enough, the nose, larynx, trachea or lungs may be affected. Swallowed saliva causes epigastric pain and vomiting. In fatal cases renal complications have been noted. Local oedema of the penis may cause retention of urine.

Lewisite resembles mustard gas in its action but is far less insidious. Unlike mustard gas it was not used during the war but was discovered since then by an American and has been given the name "Dew of Death." Its chemical name is dichlorarsinevinylchloride and its composition is expressed by the formula  $\text{Cl}_2 \text{AS}(\text{CH}:\text{CHCl})$ . It is a colourless liquid boiling at 190°C. Unlike mustard gas it has a strong odor which is best described as being like rank geraniums. It has an immediate irritating effect on the nose, throat and eyes. It also attacks and blisters the skin and its action is more rapid than that of mustard gas. Erythema occurs within thirty minutes; vesication also is early and is complete within twelve hours. At this point it can be clinically distinguished from mustard gas. The Lewi-



site blister is clearly defined; it covers the whole erythematous area and is filled with a cloudy fluid containing leucocytes and arsenic. In extensive burns acute arsenical poisoning may result. The mustard blister has a surrounding area 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 due to hydrolysis. The fine spray of Lewisite is even more dangerous to the eyes than that of mustard. Immediate signs of irritation follow. In fifteen minutes there is an acute conjunctivitis with oedema of the lids, pain, photophobia and in three to nine hours the whole picture is produced, an effect only seen with mustard at the end of twenty-four hours.

Since the presence of Lewisite is readily appreciated the respirator is put on early and protection attained, though as in the case of the Arsenic smokes the symptoms of irritation may appear even after the application of the respirator. Without one — nasopharyngitis occurs and then bronchitis, which may lead to a fatal broncho pneumonia.

There are three ways of detecting the presence of mustard gas.

- (1) Smelling it—possibly particularly by a non-smoker; as can be easily understood this is not very dependable.
- (2) Visible signs—dark brown oily stains.
- (3) Chemical apparatus—a yellow paint has been prepared which turns red on contact with mustard gas.

One of the chief things to be watched in connection with mustard is the possibility of its being present with some other easily detectable gas, for example Lewisite; then after decontamination with water which would destroy the Lewisite the mustard gas would still remain to poison the unwary.

#### *Treatment of vesicants:*

**Skin:** While droplets of mustard are visible on the skin, bleach ointment (bleaching powder and white petroleum jelly 1:1) is useful to lessen the severity of the burn. If more extensive—Bleach paste is more practical (Bleaching powder and water 1:2). The affected area is swabbed for several minutes until all odour has disappeared. But cleansing with ordinary soap and water will remove the surface gas and prevent burns if performed within five minutes. Solvents such as petrol, methylated spirit, paraffin may be used. The dresser should be completely protected. Apart from swabbing this method should not be used if erythema has begun. If mild it will clear up as will a sunburn with a slight pigmentation and desquamation. Here Tannic acid jelly is useful. With vesication one should try to avoid secondary infection.

Mustard burns should be treated surgically with thorough cleansing, if necessary under an anaesthetic and then application of layers of lint soaked in a 2½ percent solution of freshly made up tannic acid.

**Eyes:** As soon as possible, irrigation with 2% Sod. Bicarb. solution is instituted. To continue this in the presence of oedema and spasm applica-

tions of 1% sterile atropine ointment twice a day may be necessary. Moreover if the discharge becomes mucopurulent 2% argyrol twice a day is indicated. Do not bandage, or apply cocaine, just keep a shade over it and instill liquid paraffin at frequent intervals. The amount of treatment depends on the degree of contamination.

**Respiratory tract:** Warm douches of 5% Sod. Bicarb. are useful for the rhinitis. If laryngitis is present rest the voice, keep in the fresh air and give a paraffin spray or vapour inhalation.

Roughly two percent of mustard cases in the great war ended fatally, usually due to broncho pneumonia. To prevent this complication lung cases should be kept in special, warm and well ventilated wards, and cases with secondary infection should be isolated.

Patients should be sent as soon as possible to a convalescent centre, in order to prevent the development of "anxiety" neurosis and such conditions as functional photophobia and aphonia.

#### Paralysants.

The chief gases included in this section are Hydrocyanic acid and Hydrogen Sulphide. Both are extremely lethal but it is not easy to create lethal concentrations under war conditions and the respirators provided will give adequate protection against them in such a situation.

In the case of a gas attack with either HCN or H<sub>2</sub>S, diagnosis is very simple. In both cases prolonged artificial respiration with administration of O<sub>2</sub> and CO<sub>2</sub> is indicated.

#### Other dangerous gases and fumes.

The gases usually included in this group are not likely to be used as war gases but may be met with under certain circumstances. For example carbon monoxide and the nitrous fumes are generated from burning explosives, and others such as phosphorous and chlorosulphonic acid are used in the production of smoke screens.

In conclusion, the most important thing to remember is that our gas masks will protect us against all these gases which are likely to be used against us. It is very important that both soldiers and civilians should realize this fact effectively. We should also remember that panic is the best friend of gas so that discipline is at all times most essential.

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The desire to study medicine must overcome one like a summer's cloud, like love, like the measles. Usually it seizes a man unawares, either because he has grown up in a medical atmosphere or because he admires the family doctor, or because he has read or heard something that has fixed his ambition in the direction of medicine.—*David Riessman.*