MEDICAL ASPECTS OF GAS WARFARE

MEDICAL DIVISION

U. S. OFFICE OF CIVILIAN DEFENSE

TENTATIVE MANUSCRIPT
UNPUBLISHED

INTRODUCTION

Since gas warfare was introduced by the Germans in 1915 without warning and contrary to existing rules of warfare, it has gained much attention in the public press. The results attributed to the effects of war gases have been greatly exaggerated, and this weapon is wrongly credited with more iniquities than have ever been associated with any other weapon. The misinformation concerning the types and degrees of injuries produced by it has been grossly misleading.

To what extent gas should be held responsible for a great train of symptoms of which so many ex-soldiers complain is an open question. It has been blamed for every conceivable sort of ailment.

There is no doubt that a large number of ex-soldiers who are now incapacitated, and who claim that gas was responsible for their condition were exposed to gas at some time during their service abroad. Many of them were also exposed to other conditions such as the respiratory tract infections which could produce similar effects.

During the last war few observations were made on the immediate effects of war gases on individuals, because it was impossible to examine most exposed men until several hours after they were gassed. During this interval many important changes took place which could not be studied carefully.

Since the last war many investigations have been conducted which have revealed much valuable information. In this work the effects of the pulmonary irritants and vesicant gases upon the lung were studied largely on dogs. From this experimental evidence the following conclusions were drawn:

a. In the great majority of dogs gassed at sublethal concentrations changes can no longer be demonstrated two months to a year after recovery.

b. In a minority of instances permanent lung alterations are found, but the damage is not widespread, is usually confined to small areas and consists of small patches of organization, thickening of the bronchial walls with loss of elasticity and occasional occlusion of the bronchioles by organized exudate. This scarring of lung areas is usually insufficient to affect the functional efficiency of the lungs.

c. Since the lungs of dogs are more susceptible to damage than those of human beings it is reasonable to conclude that in the vast majority of surviving human patients who were not severely gassed, and who received adequate medical care in hospitals, most lesions probably healed within a short time, and that the small amount of fibrosis remaining in the minority of cases rarely caused any serious disability.

Although gas is very efficient as a weapon to produce temporary disabilities, the death rate is surprisingly low. The U. S. Army suffered 258,338 casualties of whom 34,249 died on the battlefield. Of those who died on the battlefield it is estimated that probably not more than 200 succumbed to fulminent injuries due to gas. The mortality from non-gas war wounds was 47,940 or 18% compared with 1421 who died of injuries due to gas, or a mortality of 0.5%.

Physical Properties of Gases

War gases are, for the most part, disseminated in the form of liquids or true gases. It is important, therefore, that the general principles relative to the conversion of liquids to gases, and the physical behaviour of gases be understood by the student of chemical warfare.

Partial pressure: The total pressure of a gas is the sum of the partial pressures of its constituents.

For instance, the pressure of the atoms here at sea level (760 mm. Hg.) is made up essentially of the partial pressures of O_2 (20% = 152 mm. Hg.), N_2 (78% = 593 mm. Hg.), and H_2O (2% = 15 mm.)

Vapor Pressure and Temperature: Substances can exist as solids, liquids, or gases, depending upon the temperature. The vapor pressure which a substance exerts always increases with the temperature.

For instance, water changes from solid to liquid at 0° C. The vapor pressure of water is 4.6 mm. Hg at 0°C., 17.5 mm. at 20° C., and 760 mm. at 100° C. The air is saturated with water vapor when the partial pressure of water vapor is equal to the vapor pressure of water at that temperature. The same principle may be applied to all substances, whether their partial pressures may be greater or less than that of water at a given temperature.

Density of a gas (vapor): Equal volumes of gases under the same conditions of temperature and pressure contain the same number of molecules (Avogadro). Therefore, the density of a gas is proportional to its molecular weight.

Methods of Dissemination: Chemical agents are usually disseminated as vapors or as small solid or liquid particles called smokes. When each molecule is free to move according to the gas laws we have a true gas, while the smoke particles, or aerosoles follow the laws governing colloids. Smokes are further subdivided into irritant smokes and screening smokes, depending upon their main use and physiological action. Chemical clouds are of two types - one in which a vapor is mixed with air (gas clouds), and the other, a suspension of extremely small liquid or solid particles in air (smoke clouds).

Mechanics of Evaporation: A liquid changing into a gas removes heat from the air during vaporization, while smoke materials either burn or hydrolize in air, thus generating heat. The result is that immediately downwind from the source of smoke the air is heated. The magnitude of these temperature changes is usually small but depends upon the particular material used and the concentration generated. All war gases are heavier than air. The addition of a heavy vapor and the cooling effect of evaporation in a gas cloud cause the cloud to hug the ground and seek out depressions. The concentration of vapor in a gas cloud varies inversely as the square root of the height above the ground.

Behavior of war gases upon release:

Lateral Spread: When either vapor or smoke is released into the air the cloud is blown from side to side by shifting air currents which cause a lateral spread as the cloud moves downwind. In steady winds, this spread amounts to about 15 per cent of the distance from the source. Under very unfavorable conditions when the wind is rapidly changing direction, or in a fish-tailing wind, the spread is very great. Under average conditions a cloud of any size will gain 20 yards in width for each one hundred yards traveled.

Drag Effect: Wind currents carry gas clouds along the ground with a rolling motion, since the wind velocity near the ground is almost zero but rapidly increases upward. This rolling motion causes the cloud to stretch out in length. The increase in the length of the cloud is called the "drag effect". For clouds released on the ground the drag amounts to about 10 per cent of the distance traveled over grass, plowed lands, or over water, and to about 20 per cent for gently rolling terrain covered with bushes, growing crops and small patches of scattered timber. In heavy timber the drag effect is much greater.

Vertical Rise: The vertical rise of a gas or smoke cloud depends upon several factors. A gas cloud is cooled by evaporation and tends to hug the ground. Convection currents cause a more or less rapid mixing of the gas with the overlaying air. Convection currents are most active over roads and when the ground is dry, the sun is shining brightly, and when the ground is much warmer than the air. During the day, and especially when the sun is shining, the ground surface frequently becomes from 10-50 degrees hotter than the surrounding air. The heated ground surface causes violent convection currents, known as the "running mirage". At night and in the early morning the ground surface is frequently cooler than the surrounding air and under such conditions there are no convection currents. This is the reason for firing chemical agents at night, especially during the hours from midnight to sunrise and shortly thereafter.

Persistency: The length of time an agent will remain on the ground at the point of release is called the persistency of that agent. If the remaining concentration, under conditions favorable for the use of that agent, is sufficiently great at the end of 10 minutes to require protection of any kind, that substance is said to be a persistent agent. When no protection is needed under the above conditions, the agent is said to be non-persistent.

Thus it may be said that those gases with a high vapor density and those which vaporize slowly will tend to be persistent. Gases with a low vapor density and a high vapor pressure will be acted upon quickly by convection currents and diffuse so rapidly as to be quickly dissipated below lethal concentrations.

Absorption and adsorption: Most gases have a tendency to condense upon or to be "adsorbed" by solids. In some cases this adsorption is very considerable. Charcoal has a remarkable capacity for adsorbing a great variety of gases from the air and for this reason it is used in the cannisters of gas masks. This characteristic is undoubtedly due to the fact that charcoal is finely porous and thus presents a very large surface to the condensation of gases. This process is usually spoken of as "absorption." But this is not strictly correct. The term adsorption is proper

since the phenomenon is really one of condensation on the surface of the charcoal. Absorption is, in some cases at least, a loose form of chemical conbination, while adsorption is regarded as purely physical.

Concentration: Another term which it is necessary to use in describing and explaining the effects of chemical agents is "concentration." This refers to the amount of the chemical which is present in a unit quantity of air. It is not something which can or need be accurately measured, but, if the odor of gas is sharp and strong, the concentration is low. The more of a toxic material present in the atmosphere, the more quickly and severely will one exposed to it be affected.

Hydrolysis is the reaction of any chemical substance with water whereby one or more new substances are created. This is a reaction of great importance in chemical warfare as many chemical agents are rendered harmless after a time by this reaction. If the hydrolysis product is itself a poison, as is the case with all agents containing arsenic, considerable effort is required to neutralize the agent effectively.

Absolute requisites of a chemical agent: A substance to be useful as a chemical agent must have the following properties:

a. It must be very toxic, or very irritant, or produce a large volume of smoke, or have incendiary properties.

b. It must be stable in storage and reasonably stable on contact with moisture.

c. It must be capable of manufacture on a large scale.

d. Raw materials must be available for its manufacture.

e. It must be suitable for loading in munitions and should have little or no corrosion on ordinary steel.

f. The substance must be capable of vaporazation, or other means of dissemination, in sufficient concentration, or in sufficient amounts under field conditions to produce the effect desired.

g. If the substance is a gas under ordinary conditions, it must be easily compressible to a liquid and easily vaporized when the pressure is released.

Additional desirable properties: In addition to the absolutely necessary properties, it is highly desirable that chemical agents possess the following properties:

a. It should be capable of handling and transportation without special precautions.

b. It should be cheap to manufacture.

c. It should be capable of quick production in existing commercial plants without extensive alteration in existing equipment.

d. When disseminated as a vapor the molecular weight should be several times as great as that of air (which is approximately 29).

Classification of chemical agents by physiological actions into

a. lung irritants

b. vesicant or skin-blistering gasses

c. lacrimators or tear gasses

d. sternutators, or those gases that irritate the nose and throat and cause vomiting.

e. systemic poisons.

It should be realized that this grouping is based on the most prominent physiological action. Most war gases share, in some degree, the injurious properties of others. Almost all of them, if breathed long enough will cause injury to the lungs.

LUNG IRRITANTS

PHYSICAL AND CHEMICAL PROPERTIES

CWS Symbol	Cl.	CG	PS
Common Name	Chlorine	Phosgene	Chlorpicrin
Chemical Name	Chlorine	Carbonylchloride	Trichlornitromethane
Chemical Formula	Cl_2	$COCl_2$	Cl_3CNO_2
Tactical Classification	Casualty	Casualty	Harassing
Boiling Point	-33.6°C	8.2°C	112°C
Vapor Pressure at 68°F-20°C	4993 mm Hg.	1180	1 8.28
Vapor density	2.4	3.4	5.6
Volatility Oz./1000 cu. ft.	---	---	165.0
Persistency Summer -	5 min. open	5 min. open	1 hour open
	20 " woods	20 " woods	4 hours woods
Winter -		10 " open	12 hours open
		30 " woods	Several weeks
Odor		Ensilage	Licorice
Odor detectable at Oz. /1000 cu. ft.	0.01	0.004	0.007
Min. Irritating Concentration Oz. /1000 cu. ft.	0.05	0.44	0.02 - 3 min.
Lethal Concentration Oz./1000 cu. ft.	5.6 for 10 min.	0.05 for 10 min.	2.0 - 10 min.
Method of neutralizing	alkali	steam hydrolyses	Na_2SO_3 solution

LUNG IRRITANT GASES

There are three chemical warfare agents which act primarily as lung irritants, Chlorine (Cl), Phosgene (CG), and Chlorpicrin (PS). Chlorine and Phosgene are gases under usual atmospheric conditions. Chlorpicrin is a liquid with a relatively high boiling point and so tends to be somewhat persistent.

With all three agents there is a latent period after exposure which may last as long as 24 hours before manifestations of injury appear. The latent period is likely to be short after exposure to chlorine.

PHOSGENE

Pathology: The principal lesions are pulmonary edema, rupture of pulmonary alveoli and a concentration of the blood, with increased viscosity and a tendency to thromobosis.

Relatively high concentrations of phosgene may be breathed without immediate irritation of the respiratory tree, hence the most distant bronchioles and alveoli may be affected. As a result of the irritation the permeability of the alveolar and capillary walls is increased causing a pulmonary edema. The upper parts of the respiratory tree are seldom affected by the gas.

The severity of the pulmonary edema will be proportional to the amount of gas inhaled. Following exposures to very high concentrations death may result after only a few hours. The lungs may be water logged, may be somewhat smaller than normal but will show no evidences of emphysema.

If death occurs later on the first day the lungs will be normal in size or larger than normal, there will be considerable vascular congestion and in the bases there will be patches of emphysema alternating with areas of collapse. On section frothy serum drips from the tissue and petechial hemorrhages may be seen widely scattered through the injured lung. A variable amount of serous or bloody fluid may be found in the pleural cavity.

After the first day the lungs are not so waterlogged. There is less fluid lost from the cut surface of the lung and patches of aeration are noted in the bases. As time goes on the edema gradually clears. Deaths after the third day are probably due to broncho-pneumonia rather than to pulmonary edema.

Associated with the pulmonary edema there is a concentration of the blood through loss of fluid. The hemoglobin may be as high as 150%. There is also a tendency to pulmonary thrombosis because of the slowing of circulation through the congested lung and the concentration of the blood.

With the increased resistance in the pulmonary circulation there is a gradual dilatation of the right heart which is reflected in an engorgment of the veins of the head and neck. This failure of pulmonary circulation, combined with the incomplete oxygenation of blood due to inadequate alveolar surface brings about failure of the left heart. The characteristic picture at the time of post mortem is to find the right ventricle so dilated that it presses the interventricular septum over into the space normally occupied by the left ventricle.

Disruptive emphysema is acused primarily by the violent coughing which ruptures the already damaged alveolar walls.

Phosgene ($COCl_2$) in the presence of water is hydrolyzed to HCl and CO_2. The effect it produces on tissues cannot be explained by this reaction alone, since the injury produced by phosgene is more serious than that produced by HCl. in comparable amount.

The upper respiratory tract is seldom injured by phosgene.

Symptoms of Phosgene Poisoning: Inhalations of even moderate concentrations of phosgene cause immediate catching of the breath and a sense of substernal discomfort. This may pass off rather rapidly with no further warning of injury until the onset of acute symptoms from 12 to 24 hours later.

The inhalation of very high concentrations of the gas may produce a prompt and fulminating type of injury. Pulmonary edema develops, followed by deep cyanosis and venous congestion, with death occurring in 2 or 3 hours.

The inhalation of lower concentrations, however, may cause a variety of clinical pictures.

Following exposure to moderate concentration of phosgene the patient may be a symptomatic for a period which may last as long as 24 hours. Pulmonary edema now develops very rapidly. Respiration is rapid and shallow, the chest wall fixed in the position of full inspiration. There are violent fits of coughing in which a frothy, pink sputum is raised. Cyanosis develops rapidly and may become very intense. The veins of the neck, chest, and head become distended. The pulse is of good quality and ranges about 100 per minute. The patient is said to be in the blue stage of cyanosis.

The general appearance of the patient may change rather abruptly. The livid blue is replaced by an ashen grey color resembling shock. The pulse becomes very rapid and thready. The skin becomes cold and clammy. This represents the grey stage of cyanosis. Occasionally cases of phosgene poisoning do not go through the blue stage but lapse abruptly into the grey cyanosis of asphyxia.

While in either of these stages the patient is apprehensive and restless. The eyes are staring, the lids half closed.

Mild injury is also seen in which cyanosis does not develop. The patient soon becomes drowsy and falls asleep. He may have a sense of tightness in the chest which is aggravated by coughing. He may vomit after taking food or liquids. The pulse is usually slow (40 or 50 a minute) for a few days. Convalescence progresses uneventfully unless secondary infection occurs.

Those patients with more severe injury, as indicated by blue cyanosis, do well so long as the vital centers have an adequate supply of oxygen. If the pulse does not exceed 100 per minute the prognosis is good. The edema fluid starts to clear on the third or fourth day and convalescence is rapid from that point. At any point in the course of the disease, particularly if the patient is exposed to mental or physical strains, the oxygen supply to the vital centers may be insufficient.

The pulse becomes rapid and thready, the skin clammy, the patient semicomatose.

Patients suffering from grey cyanosis frequently recover, though the death rate is very high. Many recover only to succumb to a complication, broncho-pneumonia, which is usually fulminant and highly fatal.

A less common clinical picture is occasionally encountered after exposure to moderate concentrations of phosgene. Circumstances may be such that for several hours the casualty may be inactive, not suspecting his injury. During this time changes have occurred within the lungs which reduce the pulmonary reserve to a point where additional demands of oxygen cannot be met. Should the casualty now engage in physical exertion the demand for oxygen would be beyond that which the injured lung is able to supply. There is extreme anoxemia of the respiratory and circulatory centers, often causing immediate death.

The pathology produced by chlorine or chlorpicrin is very similar to that produced by phosgene. Because they are more irritant at the time of exposure, the victim tends to get out of the area at once so that there is less liklihood of involving the entire lung as with phosgene. Chlorpicrin often causes nausea and vomiting. Chlorine frequently causes severe injury to the larynx, trachea and upper bronchi.

The clinical course following injury by any of the members of this group is very similar.

TREATMENT OF LUNG IRRITANT CASES

Cases of all degrees of severity may be met with, and it may be difficult at times to decide whether or not a man has really been gassed. The benefit of the doubt should be given to the patient in all cases, and any man showing any feature of lung irritant poisoning should be rested for 24 hours and observed. It should be borne in mind that a delayed action may be exhibited by some pulmonary irritants, but if no objective symptoms have arisen after the lapse of 48 hours the patient can be discharged.

(a) Treatment in the Acute Stage:

The essentials of treatment for acute poisoning by any pulmonary irritant gas are rest, warmth, venesection and oxygen. It is necessary to think of lungs choked by an edema fluid which may be absorbed in three or four days if the circulation can be maintained.

(1). Rest: The importance of rest cannot be exaggerated. In the earlier stages undue muscular exertion may lead to an aggravation of the symptoms. In the later stages, when the oxygen supply of the body is interfered with by pulmonary edema, any physical exertion will probably result in disastrous consequences.

All cases should be treated as stretcher cases, and their clothing loosened so as to ease breathing. If this is not practical, walking cases should be given every assistance, so that they may avoid physical effort as much as possible. Those who show definite symptoms should not be allowed to leave their beds or stretchers for any purpose whatever.

(2) Warmth: This helps to combat shock, and also to diminish the oxygen consumption that is entailed by the muscular movements of shivering. Attention should therefore be directed to this point when the patient's clothing is removed.

(3) Venesection: As soon as venous congestion begins to appear, 15 to 20 ounces (300 to 600 ccs) of blood should be withdrawn from a vein by a large bore needle. This treatment is beneficial for all cases except those of the leaden grey hue with failing circulation and a rapid, thready pulse. For this latter group it is harmful. After venesection the headache often disappears, dyspnoea is somewhat diminished and sleep usually follows. If these results follow, nothing further may be needed.

(4) Oxygen: Oxygen should always be given to casualties with serious pulmonary edema, that is, to those with any cyanosis or grey pallor. The aim should be to tide the patients over the critical period of the first two or three days, and for this purpose oxygen should be administered continuously by means of any apparatus, such as a B.L.B. Mask or a nasal catheter, that will ensure a suitable mixture with air.

The oxygen need not be warmed, and a sufficient current of it should be used (from two to ten litres a minute) to ensure a change in the patient's colour from livid blue or grey to a pink tint. If the light is insufficient to allow cyanosis to be judged, guidance may be obtained from the behavior of the pulse. This treatment must be maintained, day and night if necessary, with a progressive lessening of the oxygen supplied, until the patient no longer tends to lapse into cyanosis when the oxygen is withdrawn.

If the supply permits, oxygen should also be given to the milder cases of edema in order to prevent their lapsing into a state of asphyxia.

The experience of the last war showed that no patient in whom it was possible to restore a pink colour by the proper use of oxygen died from simple pulmonary edema. In a hospital likely to receive any considerable number of cases of lung irritant poisoning (not of broncho-pneumonia from mustard gas), it is important to provide some definite routine of oxygen administration.

b. General Treatment:

Serious cases are best treated in a well lit and well ventilated ward, protected from chill. The diet should be liquid and sparingly given in the acute stage, but bland drinks should be allowed freely.

Expectoration should be encouraged by postural drainage. The foot of the bed or stretcher is raised three or four feet for a few minutes at a time, with the idea of draining fluid from the chest; Vomiting is helpful in emptying the lungs, and often occurs spontaneously, but it is liable to produce exhaustion, and it should not be induced by powerful drugs such as apomorphine or ipecacuanha.

Expectorants should not be given to severe cases during the first two or three days for fear of increasing the tendency to cough and so augmenting the damage in the lungs. In mild cases, or when the acute symptoms have abated in the severe cases, ordinary expectorant mixtures containing ammonium salts may be given with advantage.

The most serious complications of pulmonary irritant injuries during the last war were infectious processes such as bronchitis and pneumonia. No studies have been made to date relative to the efficacy of the sulfonamides in the treatment of such infections. Inasmuch as the infectious process is usually caused by those bacteria which normally inhabit the upper respiratory tract, it may be expected that the sulfonamides will be effective. It is doubtful, however, if they should be used prophylactively because of their effect on the oxygen carrying power of blood.

If pulmonary complications develop (such as infective bronchitis, broncho-pneumonia, etc.) the patient should, if possible, be treated in a separate ward; otherwise, he should be separated by at least six feet from his nearest neighbour.

No drugs were found to be of any special value in the last war. Atropine did not prove effective in checking edema or in relieving bronchial spasm. The faster acting barbituates will generally be satisfactory for the control of restlessness. Morphine is dangerous because it tends to produce anoxemia and should only be used in small doses (1/6th gr.) to control extreme restlessness. The relief of asphyxia by oxygen is the best means of relieving headache and the best cardiac stimulant is oxygen.

(c) Treatment in the Convalescent Stage:

No case should be moved for purposes of convalescence until definite cyanosis or other severe symptoms have disappeared. It is also very important that a note of the special symptoms attending the acute illness should be forwarded with each case in order that subsequent treatment may be properly applied. The milder casualties are likely to recover after a short rest; those who have passed through a stage of severe cyanosis, however, or who have suffered from a complicating broncho-pneumonia require a prolonged period of convalescence.

All except the more severe cases should be gotten up from bed as soon as possible; slight bronchitis or gastric disturbances, which usually are only temporary, do not contraindicate this, but cases of abnormally rapid or slow pulse should be rested a little longer.

A system of carefully graduated exercises should be instituted with full opportunities for lying down and resting in the intervals. The response to exercise of each individual must be carefully studied. Exhaustion must be guarded against as symptoms of "disordered action of the heart" (effort syndrome) may develop, and add weeks or months to the period of convalescence.

Employment of Anesthesia for Chemical Casualties: When anesthesia is necessary for wounded casualties who have also been exposed to lung irritant gases, local infiltration or nerve block is the method preferred, but intravenous, spinal, or rectal routes may be employed. At times these methods are neither available nor desirable, and in some cases within certain restrictions it may be practicable or necessary to use inhalation anesthesia.

During the latent phase of pulmonary irritation, surgical interference must be confined to life-saving measures such as those necessary in laryngeal-tracheal injuries, hemorrhage, etc., and if anesthesia is necessary its use should be as brief as possible.

When inhalation anesthesia is definitely indicated, ether shoud be avoided in favor of less irritant anesthetics. In situations where the use of spinal anesthesia is being considered it should be remembered that it may predispose to the development of cardivascular collapse which so often occurs following exposure to pulmonary irritants.

If pulmonary edema has developed, the treatment of this condition is more important than surgical treatment of any accompanying injuries, and general anesthesia is absolutely contraindicated. If the patient survives the edema all surgical interference should be deferred for at least 48 hours.

AFTER-EFFECTS OF POISONING BY LUNG IRRITANT GASES

Apart from infective broncho-pneumonia, which usually appears towards the end of a week, the sequelae of poisoning by the asphyxziant gases are, contrary to popular belief, much less grave than was anticipated in the last war. The great majority of cases were restored to good health. Some continued to show incapacity for strenuous or even moderate exercise. This was often associated with tachycardia and a rapid, shallow type of breathing. Recurring frontal headache, generally worse after exercise, and epigastric pain of a temporary nature were frequent. While pain in the chest was variable, the presence of a mild bronchitis was found in an appreciable proportion of cases.

In the last war, the two important, sequelae which tended to prolong invalidism were "disordered action of the heart" (effort syndrome) and nocturnal "asthma."

"Disordered action of the heart" (irritable heart, or effort syndrome), is a condition characterized by precordial pain, a sense of exhaustion, dyspnea and persistent tachycardia after exercise but no evidence of organic heart disease, was the commonest and most persistent after-effect. A small proportion proved intractable, and there was evidence to show that invalidism was increased if men were pressed to physical effort too early and too fast during the beginning of convalescence.

Nocturnal asthma, which differed from the ordinary asthma of civil life, took the form of spasmodic attacks, lasting from three to thirty minutes, with shallow and rapid, but not difficult, respirations and with no abnormal physical signs in the chest during the attack. The pulse might be slow and full, or rapid and almost impalpable, and both the haemoglobin percentage and the red cells were increased.

Both disabilities almost always yield in time to a slowly progressive routine of graduated exercise, coupled with careful supervision and feeding, and firm reassurance to dispel neurasthenic factors.

Patients who have passed through a phase of infective broncho-pneumonia should always be considered as a group apart.

INVALIDISM AFTER LUNG IRRITANT POISONING

Until knowledge came through clinical experience, there was much apprehension in the last war concerning permanent damage to the lungs following the inflammation caused by chemical irritants. It was thought that severe emphysema and fibrosis of the lungs, or perhaps pulmonary tuberculosis, might result among the survivors. Nothing so gloomy occurred.

It soon became evident that men who have suffered from the most severe cyanosis with acute pulmonary edema could recover rapidly and completely. Many went back to full military duty after a convalescent period of from three to four months. Others, as described above, suffered from neurasthenic features of exhaustion or from temporary loss of wind and endurance. But a small proportion did develop permanent disability, with progressive dyspnea, recurrent bronchitis and a radiographic picture of scattered fibrosis and emphysema in the lungs. Since it was proved that a man could recover completely from the effects of the chemical irritant, it is probable that these rare examples of chronic invalidism were due to slow fibrosis caused by the secondary complications of broncho-pneumonia.

As regards tuberculosis, a general survey of the situation in the last war was made, and it soon became evident that, in spite of what was being written in certain countries, there was, as would seem logical no ascertainable connection between gassing and tuberculosis. On the other hand, gas may aggravate pre-existing tuberculosis.

VESICANTS

PHYSICAL AND CHEMICAL PROPERTIES

CWS Symbol	HS.	M-1.	ED.
Common Name	Mustard gas	Lewisite	Ethyldichlorarsine
Chemical Name	Bisbetachlor-ethyl sulfid	Bichlorvinyl-dichlorarsine	Ethyldichlor-arsine
Chemical Formula	$(ClCH_2CH_2)_2S$	$(ClCh:CHAsCl_2)$	$C_2H_5AsCl_2$
Tactical Classification	Casualty	Casualty	Casualty and Harassing
Boiling Point	228°C.	190°C.	156°C.
Vapor Pressure at 68°F. - 20°C.	0.065 mm Hg.	0.395 mm Hg.	5.0 mm Hg.
Vapor Density	5.4	7.1	6.5
Volatility Oz./1000 cu. ft.	0.57	4.5	47.0
Persistency	5-10 days, open 2-3 weeks, woods In winter, several weeks, open and woods	In summer: 24 hours, open 1 week, woods; In winter, 1 week	1-2 hours open, 2-6 Hours, woods; In winter: 2-4 Hours open; 12 hours woods
Odor	Garlic or Horseradish	Geranium	Biting
Odor detectable at Oz/1000 cu. ft.	0.0005	0.0014	0.001
Min. Irritating Concentration Oz./1000 cu. ft.	0.0004 - 1 hour (eye injury conc.)	0.0008	0.004
Lethal Concentration Oz.1000 cu. ft.	0.15 - 10 min.	0.12 - 10 min.	0.5 - 10 min. (by breathing)
Method of neutralizing	Bleach powder 3% Na_2S	Alcoholic NaCH spray	NaOH solution

MUSTARD GAS

Lesions Due to Liquid Mustard Gas:
Skin Burns

Mustard gas has a high lipoid solubility which results in rapid penetration of the skin though some time may elapse before clinical manifestations occur. The initial signs and symptoms of a typical liquid burn are an erythema accompanied by itching. Vesicles develop in 8 to 12 hours. They vary in size from very small to very large ones, depending upon the size of the contaminated area.

The blister of mustard is painless, flat, and surrounded by a zone of erythema. The vesicles have a tendency to coalesce. They are prone to become infected.

In the central area of the lesion capillary engorgement is prominent and frequently goes on to deep cyanosis with necrosis of tissue. If the burn is severe, necrosis may result without vesication. The vesicles tend to be flaccid though some rupture spontaneously.

The vesicle content is at first a clear, watery, serous fluid. The fluid becomes cloudy, as bacterial invasion occurs--the usual course unless it is drained. The vesicular fluid is non-toxic and non-irritating (in contra-distinction to that removed from lesions caused by Lewisite.)

If the vesicle is opened early, the base is found to be pink in color. This is shortly replaced by a gray sloughing membrane which begins to separate about the sixth day. The separation of the slough is accompanied by healing of the lesion which is, in most instances, well advanced by the third week. Those lesions which involve the deeper layers, result in marked vascular destruction tending to cause a protracted healing period. The scar is fibrous, of low vitality, and often has a copper-colored pigmentation which tends to clear with time.

If clothing becomes contaminated with liquid mustard, the heat of the body will vaporize the liquid and a vapor burn may result. If clothing is wet it is penetrated more rapidly by the gas than if dry. Of course, the thickness of the clothing and the amount of contaminant will govern to some degree the rate of penetration.

EYE BURNS DUE TO THE LIQUID:

Contamination of the eyes by liquid gas is a very serious injury, frequently resulting in permanent disability.

Following contamination there is generally a period of irritation. This frequently passes off quickly leaving the patient without symptoms for a short time. Usually within 30 minutes of injury symptoms of acute conjunctivitis are experienced by the patient, and these rapidly become severe. Photophobia, lacrimation, and pain are prominent.

There is an intense edema of the lids and of the bulbar and palpebral conjunctive. The cornea is cloudy and opacities are often seen. Intra-ocular tension is increased in most instances. The lacrimation is shortly replaced by a muco-purulent discharge and secondary infection commonly occurs.

The extensive destruction of the conjunctiva favors the development of symblepharon as healing occurs. Permanent opacities of the cornea are liable to result.

GASTRO-INTESTINAL TRACT

Liquid mustard gas may be ingested in contaminated food causing damage to the mucous membrane of the gastro-intestinal tract. This results in vomiting of mucus and blood, and severe epigastric pain.

LESIONS DUE TO MUSTARD VAPOR

(a) EYES:

Signs and symptoms of injury due to mustard vapor in the unprotected individual are generally first observed in the eyes. At the time of exposure there is no sense of irritation, and clinical manifestations may not appear for as long as 24 hours. Smarting and lachrymation, the first symptoms, are quickly followed by pain and photophobia. The lids and conjunctiva become edematous. A muco-purulent discharge indicates the presence of secondary infection. Chemosis may be of such a degree that the conjunctiva protrudes between the lids, interfering with drainage.

The cornea is often hazy in the early stages, the haziness fading above and below where the cornea has been shielded from the gas by the lids. The corneal epitheleum loses its lustre. Exfoliation of the corneal epithelium may occur. Ulceration is seldom encountered unless the cornea is traumatized.

As recovery takes place the edema gradually recedes in the cornea and its lustre is regained. In the absence of corneal ulceration or conjunctival adhesions, serious complications are seldom encountered. Lachrymation and photophobia are liable to persist and neurasthenic conditions may occur in susceptible individuals.

Eye injuries by mustard vapor in the war of 1914-18 fell into 3 main groups clinically:

(a) mild cases, 75% - fit for duty in 2 weeks

(b) intermediate cases, 15% - recovery in 4 to 6 weeks

(c) severe cases with corneal change - 10% recovery in 2 to 4 months, with a small percentage having permanent visual impairment.

(b) SKIN:

The severity of the injury to skin after exposure to mustard vapor

is influenced by a number of factors. All clothing will sooner or later be penetrated, but thick, closely-knit, clothing tends to retard penetration. Injuries are liable to be most severe where sebaceous glands are abundant, as in the axilla or groin. Wet or sweaty clothing absorbs the vapor in larger amounts than dry clothing. Thin or traumatized skin is more susceptible to the effects of mustard.

A generalized erythematous blush occurs, accentuated in the axilla, perineum, and often over the cubital and post popliteal spaces. The thick tough skin of the scalp and the palmar surfaces of the hands frequently escapes injury.

The redness deepens and, generally by the second day after onset of symptoms, vesicles make their appearance. The vesicles tend to coalesce.

The course and pathology of the blister caused by the vapor is the same as that already discussed under injury due to liquid mustard. Very mild cases may not progress to the blister stage. Flaky desquamation usually occurs. In the absence of very deep or extensive burns or secondary infection, systemic reactions seldom occur.

(d) DIGESTIVE TRACT

If saliva or nasal secretions contaminated by mustard are swallowed, a chemical gastritis results. Epigastric pain, nausea and vomiting are characteristic symptoms. The condition rarely lasts more than 48 hours. The rest of the gastro-intestinal tract is seldom involved. Permanent injury is not caused, though functional nausea is occasionally seen.

(d) RESPIRATORY TRACT

Inhalation of mustard vapor results in the destruction or injury of the cells of the respiratory tract. There is no sensation of irritation at the time of exposure to the ordinary field concentration of the gas (unlike Lewisite). The patient breathes normally, so that the vapor gains access to all parts of the tract.

Symptoms appear for from 4 to 6 hours or longer, after exposure. At this time there may be some smarting of the nasal mucus membranes. The laryngeal mucosa becomes inflamed and edematous. Hoarseness or aphonia are prominent. In severe cases the vocal chords may slough.

In severe cases the mucosa of the trachea and bronchi are affected much the same as the skin. An intense inflamation results with death of the superficial layers of cells. Secondary infection is liable to occur in the area of the sloughing membranes. As the septic sloughs accumulate, the infection may spread into the alveoli resulting in localized areas of broncho-pneumonia.

HOSPITAL TREATMENT FOR CASUALTIES SUFFERING FROM MUSTARD GAS INJURIES:

Before a mustard gas casualty is admitted to a hospital it is

essential that he undergo decontamination so as not to expose other patients about him to the agent. It is preferable that decontamination stations be established near the site of the incident so that decontamination may be accomplished as soon after exposure as possible. However, as a certain percentage of patients will be brought to the hospital in a contaminated state, arrangements must be made for decontamination after arrival.

Hospital care consists principally in symptomatic ministrations to the injured and steps to prevent secondary infection. These will be discussed by systems.

Eyes:

Much can be done to make the patient comfortable by lavage with a saturated solution of boric acid or a 2% sodium bicarbonate solution. The patient should be placed in a darkened, quiet, room. No dressings should be applied. The pupils should be widely dilated with 1% atropine solution. Dilatation should be maintained as long as there is uveal tract involvement. Boric acid ointment (5%) or a mildly antiseptic ointment, such as 1:5000 bichloride or mercury, are beneficial in preventing crusting and adhesions of the lids, but should not be used in the first 24 hours. Hot boric acid compresses every 2 to 4 hours will be found comforting and beneficial. For very severe eye pain due to corneal ulceration 1% pontocaine or 2% butyn ointments may be used but for the average case no anasthetic ointments are advocated. A 2½% solution of sulamyd is effective in reducing infection of the eye and conjunctiva. Ten to fifteen drops of the solution should be instilled in each eye with a medicine dropper every few hours. Cocaine in all forms is contra-indicated because of its effect upon the corneal epithelium. Infected corneal ulcers should be cauterized with liquid phenol. Special attention should be directed toward the prevention of symblepharon.

As convalesence becomes apparent by the lessening of conjunctival inflammation a mildly astringent solution such as

Zinc Suplhate gr 1
Sat. Sol. Boric Acid oz. 1

may be applied to the palpebral conjunctiva.

TREATMENT OF THE RESPIRATORY TRACT

Rhinitis:

A short time after the onset of eye symptoms smarting and burning of the nasal mucosa develop. In some cases severe headache develops, especially of the supra-orbital or maxillary variety. Warm deuches of a 5% solution of sodium bicarbonate several times a day are very soothing. The danger of infection is greatly reduced by the use of a 15% solution of sulamyd. This should be sprayed in the nose and throat every few hours using a non-metallic atomizer. In a few instances injury may be so severe that ulceration of the nasal mucosa occurs. In such cases epistaxis is likely to be profuse and persistent. If symptoms are unrelieved by the bicarbonate irrigation the following solution may be useful for local application:

Zinc Sulphate gr. 1
Sat. Sol. Boric Acid oz. 1

Laryngitis: Medicated liquid parrafin may be used as a spray to relieve the harsh dry cough. Steam inhalation using tr. benzoin in boiling water is especially soothing.

Bronchitis and Broncho-pneumonia: Most of the deaths from mustard gas injury result from secondary infection of the damaged lung. It is necessary, therefore, to segregate those patients showing evidence of sepsis from those who are "clean."

Gas casualties with pulmonary injury who develop septic complications such as bronchitis or broncho-pneumonia should receive the general treatment applicable to those diseases. The common invading organisms are those which normally inhabit the upper respiratory tract, and it may be anticipated that the sulfonamides will be effective in thereapy.

Expectorants are of value if the mucous is tenacious. Oxygen therapy is indicated in the presence of cyanosis. Venesection is contraindicated in the treatment of broncho-pneumonia following mustard gas injury of the lung.

Skin: Sepsis is the most serious complication of burns of the skin since it may result in general reaction and always delays healing. It is important, therefore, that careful and thorough washing of the skin be accomplished as early as possible. It should be recalled that trauma to injured skin must be avoided, as even slight trauma from an ill-fitting dressing may aggravate the gas injury. It should be repeated that bleach will aggravate a burn if applied to an erythematous area. Hair is a source of infection and it should be removed by shaving.

As the type of treatment to be applied will be governed by the severity of the injury we shall discuss each type of skin injury separately.

Erythema: Skin injury of this degree may be likened to sunburn in its severity, discomfort and duration. Spontaneous improvement with desquamation and occasionally a temporary pigmentation may be expected. For itching powdered isoamyl salicylate is very effective.

Vesication: Skin devitalized to this extent is very prone to secondary infection and the greatest care should be exercised to prevent this complition. Eary cleansing of the skin around the vesicles with the usual surgical antiseptics is of value though these solutions are too caustic to be used on the burned areas. The blistered area should be cleaned gently with an ample amount of soap and water.

If the vesicles are discrete they may be evacuated under sterile conditions with a syringe and needle. The intact epithelium may be allowed to seal the raw surface and the wound covered with a dressing. An alternative is to remove the epithelium after the vesicle has been evacuated in which case cod liver oil dressings should be applied daily.

If larger vesicles develop they should be drained after which the epithelium should be removed.

The skin lesions following vesicant injury have a tendency to increase in size for several days. The crusting techniques applicable to most thermal injuries are therefore unsatisfactory because the crust does not make contact with healthy skin at the expanding periphery of the lesion.

It is wise to keep the entire lesion covered with a sterile dressing. Mild antiseptics should be applied to the healthy skin around the burn as infection is liable to arise at the margins of the wound if the surrounding skin is not properly cared for.

The general principles of wound care should govern the treatment of the burned area. Stimulating ointments such as scarlet red may be of value in the later stages. Pinch grafts may be used on large, clean wounds with a healthy granulating base.

Septic wounds should be treated by the usual methods including hot saline or magnesium sulphate compresses. Such patients should be isolated from the "clean" cases.

Patients with burns about the perineum will receive a great deal of comfort from sitz baths at body temperature.

Functional after-effects: These fall into two main categories--In the first, patients of unstable personalities may develop neuroses from an exposure to a minimal and even non-toxic amount of mustard gas. This anxiety state is aggravated if the patient is not given proper consideration.

The second class is a more important one, because the organic lesions of mustard gas set up irritant reflexes such as coughing or photophobia which are perpetuated by introspection long after the organic lesion has cleared. Lack of understanding of such a possibility on the part of the medical officer may result in a prolongation of the disorder.

Function aphonia and photophobia are the most common of these disorders. This is not surprising since the initial trauma affects two highly specialized organs of sense, the loss of which would be most disabling to the individual. Ill-advised, unnecessary or unduely prolonged treatment tends to accentuate the condition. Maintaining the patient in a darkened room longer than necessary for an eye injury is liable to provoke psychic complications.

Aphonia on a functional basis is generally accompanied by a harsh, dry cough. Occasionally the cough is associated with the expectoration of a watery sputum of salivary origin. If the medical officer will inspire confidence in the patient as to his early recovery and have him take breathing exercises many of the symptoms will clear.

Effort syndrome is a common complication of mustard gas injury and requires experience for proper management. Early approach by a competent psychiatrist is most beneficial.

Of very definite value in reduction of psychic disorders is the early discharge of patients to convalescent centers. This should be carried out as soon as convalescence is well developed and the danger of septic complications has passed.

Doctors should realize that gas poisoning, whatever the chemical irrtant concerned, does not in itself cause a permanent poisoning of the patient or chronic impairment of health. It is necessary to insist on this truth lest the patient be allowed to develop a morbid dread and drift into neurasthenia and general debility.

LEWISITE

Lewisite is a clear or light brown oily liquid which gives off a colorless vapor having an odor like geraniums. The gas quickly causes a biting sensation in the nose. The gas has a freezing point of 10° F. so that is remains a liquid at a much lower temperature than mustard. In the presence of water, lewisite is a rapidly hydrolyzed, the products being hydrochloric acid and an insoluble arsenic compound having vesicant properties. The gas is soluble in lipoids and lipoid solvents. It has about one seventh the persistency of mustard--therefore it vaporizes relatively rapidly. It penetrates tissue much more rapidly than mustard. The liquid is much more irritant than liquid mustard.

Lewisite is both a lung irritant and vesicant chemical, more rapid than mustard in its action, but not so insidious because of its pungent, penetrating odor and the immediate discomfort experienced on contact with or inhalation of the gas.

Pathology: Injury due to lewisite produces pathological changes very similar to those already discussed under mustard. The vesicles of lewisite contain the toxic hydrolytic products of the compound, i.e., substances with vesicant properties and which are capable of producing degenerative changes in the heart, kidneys and liver by virtue of their arsenical content.

Injury due to Liquid Lewisite

Skin: Lewisite attacks and penetrates the bare skin. It produces an immediate sense of irritation which usually persists.

Erythema develops in from 15 to 30 minutes and at this stage the lesions of mustard and lewisite have an identical appearance. Vesication is usually fully developed within 12 hours.

The lewisite blister is sharply defined and extends over most of the area of erythema (in contradistinction to the vesicle of mustard which is surrounded by an angry, erythematous zone). The fluid is cloudy or opalescent and on examination it is found to have a high leukocyte count and to contain arsenic.

Serious injury from absorption of arsenic from lewisite lesions may be expected if large areas are involved and the blister fluid is not promptly drained.

On clothed skin lewisite is definitely less effective than mustard. If the clothing is wet or damp the liquid will be quickly hydrolyzed unless massive contamination has occured. It is also known that even with dry clothing small drops of liquid lewisite are not as effective as drops of mustard of similar size.

Unless contamination is massive or clothing very thin and dry it is unlikely that injury due to the liquid will result to the clothed skin. Injury is much more likely to result from the vaporization of the liquid on the clothing.

Eye Burns due to Liquid Lewisite: Injury of the eye due to liquid lewisite, however small the dose, creates a grave emergency. The patient has immediate pain quickly followed by lachrymation, photophobia and redness, all of which make their appearance within 10 minutes to half an hour after injury. These symptoms progress very rapidly. Within 24 hours chemosis, redness and ulceration of conjunctiva and cornea may be alarming. The cornea may become hazy.

The prognosis is serious since most such injuries result in some degree of permanent disability.

Injury due to Lewisite Vapor

Eyes: Even in low concentrations lewisite may be detected by its characteristic odor. If a respirator is donned at once complete protection of the eyes is afforded. There is immediate irritation of the eyes on contact with lewisite vapor. This stimulates lachrymation, the flow of tears hydrolyzing the gas.

Action on the Respiratory Tract: The irritation of the vapor forces the exposed person to apply his respirator which will effectively protect him from injury to the respiratory tract. If the respirator is not used the pathology and symptoms resulting are similar to those for mustard gas injury except that they are much more acute.

Lewisite Vapor on the Skin: In similar concentrations lewisite vapor is not as caustic as that of mustard. However, because of its low freezing point it will be more damaging than mustard vapor in cold weather.

Wet clothing will hydrolyze the vapor as it does the liquid. Dry clothing absorbs the vapor making it dangerous to wear.

Prophylaxis and prevention are discussed in First Aid in the Prevention and Treatment of Chemical Casualties.

Treatment Should be directed toward the symptomatic relief of the patient as outlined under mustard gas injuries. A preliminary bath should

be given to protect against infection and to remove any remaining chemical.

If vesication occurs the blister should be drained, the epithelium removed and the wound irrigated with normal saline to remove any traces of arsenic which may be present. The area should then be irrigated with 2-3% hydrogen peroxide. As pointed out before the blister fluid contains a vesicant agent, and it will therefore be necessary to protect the skin around the vesicle from contact with the liquid. This may be achieved by the application of a bland ointment, such as boric acid or petrolatum.

If burns are deep and are not too extensive, perhaps the most satisfactory method of management is the complete excision of the burned area including an ample margin around the area of apparent involvement. This wound may be closed by sutures, and if proper surgical technique is employed, healing by primary intention may be anticipated.

Some studies have been made as to the advisability of injecting oxidizing agents directly into the tissues of the involved area in an effort to destroy the vesicant agents in situ. The data available on this technique are not conclusive, but there is room for doubt as to the advisability of such procedures since injection of most of materials advocated may cause devitalization of tissues.

Systemic effects of arsenic absorption should be guarded against by a high fluid intake (and output) and large amounts of carbohydrate, which should be given intravenously is necessary. Vitamins, especially the B complex, should be given for their anti-neuritic properties.

Treatment of burns of the eye is the same as that outlined under mustard.

GAS INJURIES TO THE EYE

Following the early use of mustard gas by the German army in 1917, 120 eye casualties were reported. Many were exposed to gas without knowing it at first and in a few hours they developed photophobia and blepharospasm. Cases who sustained injury could be divided into three classes:

1. Mildly affected cases with little or no corneal infection--about 75%.

2. Moderately affected eyes with slightly roughened cornea, but not staining with fluorescein - about 15%.

3. Severe cases with the cornea definetely staining and corresponding conjunctival involvement - about 10%.

The first class was fit for duty in one to four weeks, the second in four to six weeks, and the third sent home and required various periods for convalescence. There were a small number of liquid burns of the eyes and eye lids.

Pathological Changes:

Class (1) - Dilated vessels in the exposed area due to direct irritation. The injection soon subsided.

Class (2) - No speciment actually examined.

Class (3) - Eyes removed in cases of death showed a denudation of the corneal epithelium with the flattening of the remaining cells. The white appearance of the conjunctiva in the early stage was due to coagulation and arrest of circulation in the conjunctival vessels. In the late stages the appearance was reversed, the exposed area being injected and the vessels sometimes remaining permanently enlarged while the rest of the conjunctiva assumed its normal appearance.

Clinical Picture: All classes suffered from photophobia and blepharo-spasm.

Class (1) - Moderate to acute injection of exposed conjunctiva, the rest of the eye being relatively unaffected. Cornea unaffected.

Class (2) - The bulbar conjunctiva covered by the lids was usually white but the conjunctiva in the interpalpebral fissure was congested. The cornea was often hazy, but did not stain.

Class (3) - The bulbar conjunctiva was white and the destruction was more pronounced than in class (2). The cornea showed an "orange-skin" roughness and in many cases stained for a variable period.
Clinical signs of the acute stage:

The patient is fairly comfortable for two or three days. Photophobia lacrymation and itching become pronounced. Photoneurosis may occur in a number of individuals of a burned group because of symptoms observable in others. Lid edges are moistened and red, a white secretation occurs at the inner canthus, probably due to desquamated epithelium, especially after the use of strong antiseptics. Severe ciliary

injection is absent, but there is great congestion of the larger conjunctival vessels. There were usually several areas of corneal ulceration at about five or seven o'clock.

1. If these areas consisted of superficial stippling and pain was fairly severe, recovery was the rule. This apparently was a sign that the corneal nerves were viable and deep corneal edema was not present.

2. If a white, band-like area extended across the cornea and there was little pain and redness, corneal sloughs and permanent disability were frequent. If the patient had been previously injured by mustard, ulceration of old areas usually recurred. The slit-lamp showed sloping sides and swollen epithelium around the periphery of the ulcers. Dark lines, probably swollen nerve fibers were seen in all layers of the cornea. They appeared like cylindrical vacuoles. Some of them were branched. Folds in Descemets were numerous. There were usually signs of iritis with posterior synechia and dilated iris vessels.

Clinical signs in the chronic state:
One of the most important signs in this stage was known as "Marbling." The conjunctiva sloughed and there was an absence of small vessels leaving large areas of the sclera bare. Here and there a large distended vessel was seen, becoming more tortuous as it neared the limbus, ending in a small cork-screw. The cornea was insensitive. Superficial corneal damage was usually in the lower third; deep corneal damage was shown by infiltration upward.

The effect of previous treatment on delayed keratitis:
The cases which had had a tarsorrhaphy did best. Those treated by lubricants alone aid not do so well. The ones treated by antiseptics and cocain did the worst.

Contact glasses:
The therapeutic use of glasses did not help, sometimes it caused the conjunctiva to swell so there was difficulty in removing the glass. They were important for improving visual function later.

Treatment: Persons who have serious damage to the eyes following exposure to vesicant vapor and all who have had any liquid contamination of the eye should be admitted to a hospital. Upon admission the conjunctival sacs should be carefully irrigated with 2% sodium bicarbonate solution. Ointments should be avoided in the early treatment of vesicant injury to the eye because the gases are lipoid soluable and so are held in intimate contact with the eye.

The visual acuity should be noted shortly after the admission of the patient. This is of great psychic value as it demonstrates to the patient that he can see. It is also a valuable part of the clinical record. Secondary infection of the cornea usually makes its appearance early and is ushered in by a discharge of mucopurulent material. Instillations of 2% sulamyd are very effective in reducing infection. 5 to 10 drops should be placed in each sac every 3 or 4 hours. In the World War solutions of boric acid, normal saline and sodium bicarbonate were used for eye irrigations. No dressings should be applied during the acute phase.

The pupils should be widely dilated with 1% atropine solution as long as there is evidence of involvement of the uveal tract. Ointments should be avoided for the first 24 hours after which bland ointments such as 5% boric acid or very mildly antiseptic ointments such as 1:5000 bichloride of mercury preparations may be used. Hot boric acid compresses every 2 to 4 hours will be very comforting. For very severe eye pain 1/2% pontocaine or 2% butyn solutions should be used to reduce blepharospasm and thus aid in the administration of local therapy. Anasthetic ointments should not be used. Cocaine in absolutely contraindicated.

The management of the acute stage of vesicant injury to the eye is frequently complicated by the intense edema of the conjunctiva. This not only serves to make local therapy difficult but by pressure on the globe interferes with the blood supply at the limbus. Early canthotomy will serve to lessen the difficulty of local therapy and, by relieving the tension produced by spasm of the obicularis, reduce the pressure on the globe.

Canthotomy is a simple procedure which seldom should require anasthesia or special training. A pair of blunt pointed scissors is slipped between the globe and the outer canthus and a cut is made laterally.

Delayed Reactions: Following injuries to the eye in which a large portion of the palpebral conjunctiva is destroyed, degenerative reactions of the corneal epithelium are liable to occur. This phenomenon, usually starting a week or two after the initial injury, is probably due to a mechanical or toxic factor. A violent keratitis occurs frequently resulting in a permanent loss of visual function in the affected eye. It is impossible to anticipate from the examination of the original injury whether these degenerative changes will occur in any given case. It is felt by some that in cases with extensive damage to the palpebral conjunctiva early surgery consisting of the extensive removal of the damaged tissue is indicated. Such procedures should only be executed by a competent ophthalmic surgeon.

Results of gas burns of the eye: A large proportion recovered with no effects in from two to three weeks. In a small percentage delayed corneal degeneration caused permanent impairment of vision in various degrees. The severe late results led to exfoliation of the corneal epithelium with Bowmans membrane being exposed in a few cases.

Where permanent disability resulted it was usually due to delayed effects such as low grade keratitis, secondary iridocyclitis, and ulceration of the cornea. Abscesses of the cornea occasionally formed which perforated into the anterior chamber making enucleation necessary.

HOSPITAL INVESTIGATION AND TREATMENT OF CASES OF GAS POISONING.

INTRODUCTORY

The main clinical features of gas poisoning by pulonoary irritants (Phosgene group) and vesicants ("mustard" group), and the general principles of treatment were established by the experiences of the last war. Additional knowledge has accrued since then from animal experiments and accidents to humans. It will be accepted, however, that many problems have remained unsolved or incompletely solved and if gas is used by enemy in new forms or greater concentrations, new problems must inevitably arise. In such an event, it would become an urgent necessity to gather reliable information as quickly as possible in order to provide general instruction (throughout the country and in other theatres of war) concerning the recognition of special clinical phenomena and the proper treatment. The intimate investigation of small numbers rather than scattered and incomplete and uncontrolled observations on large numbers would be best calculated to provide the information required.

It is proposed therefore that in each area one younger clinician should be nominated who could, at short notice, be put in undisturbed charge of cases, wherever they might occur in the area, so as to insure adequate physiological and pathological investigation.

I. Notes on the Indentification of Gas Casualties.

This part is intended to serve two purposes: (a) to give the authorities accurate data on which to determine whether gas has in fact been used by the enemy. Speed and exactness of observation are the essential requirements. The investigating officer is not expected to fill in every detail of the form, and indeed, it is better to leave the form incomplete than to make vague observations; (b) to give the authorities as complete a picture as possible of the whole incident, to enable them to determine what kind of gas has been used and the circumstances in which it was employed. Time is of less importance, and the principle stated above holds good: that the intimate investigation of small numbers is likely to provide the most useful information.

II. Notes on the Reception and Management of Gas Casualties in Hospital.

These notes are intended for the guidance of the Medical Superintendent and the physician whose duty it would be to take charge of the reception, sorting, and care of gas cases. A "team" for the treatment of gas cases should be organized in every hospital capable of receiving such casualties.

III. Notes on the Observations required in Cases of Gassing.

These notes are intended for the guidance of the clinician ap-

pointed to take charge of gas cases in each area. They form the basis of a more or less uniform investigation and research which should be conducted throughout the country. The form should not be regarded as a rigid framework of research, but rather as a guide to the minimum series of observations, which can be elaborated in one direction or another, according to the special interests of the investigator. Any new phenomenon observed, however, or any promising line of advance in investigation or treatment, should be at once reported to the Chemical Warfare Service of the United States Army.

INDENTIFICATION OF GAS CASUALTIES

Accurate answers are essential; it is better to leave the form incomplete, and add footnotes, than to give vague comments.

PART 1. GENERAL INFORMATION

Name: Approx. Age:

Address: Sex:

CIRCUMSTANCES OF EXPOSURE

1. Patient alive/dead when found.

2. Exact place of exposure:

   Town or District:

   Position: e.g., open air; inside a building, crater, or elsewhere; (specify):

   (Write in the appropriate word; do not underline)

3. Was an enemy attack in progress at the time? e.g., air raid, bombardment, etc.

   What other evidence was there of enemy damage?

4. Time of Exposure A.M. P.M.

5. What was casualty doing at time of exposure?

6. Weather: A. Warm cold

   B. Sun rain mist fog

   wind direction of wind

7A Was respirator put on

a. before gas was suspected?

b. after gas was suspected?

how long after gas was suspected?

7B Was protective clothing worn

a. before gas was suspected

b. after gas was suspected

8. If not, was the ordinary clothing contaminated

a. with vapor

b. with liquid

Was any of the clothing discarded?

8a. Was the smell of gas apparent?

What kind of smell?

9. Was there contact with the gas as a

a. vapor

b. spray

10. First Aid treatment.

How soon given?

Eyes?

Skin?

Other?

11. Was any subsequent treatment given?

If so, where?

What was done?

Signature
Office or rank
Post or station

Footnotes

IDENTIFICATION OF GAS CASUALTIES

PART 2. NOTES FOR CLINICAL DIAGNOSIS.

A. HISTORY.

1. First sensation after exposure:
2. Did the first sensations pass off soon and, if so, when?
3. First sympton of illness:
4. Time-lag between exposure and first symptom:
5. Patient's activities after exposure:
   (a) Did he walk for assistance?
   (b) If so, approximate distance and time:
   (c) Could he walk easily, or was he breathless?
   (d) Was he transported by stretcher?

B. PRESENT CONDITION

1. Present complaint:
2. Is the patient obviously ill?
3. More ill than he feels, or the reverse?
4. Systematic examination:
   (a) Skin:

Cyanosis	Pallor
Pigmentation	Jaundice
Erythema	Blisters
Burns	Necrosis

(In each case state or sketch the area affected.)

(b) Eyes:

Pain — Lacrimation

Blepharospasm — Conjunctivitis

Vision impaired — lost:

(c) Respiratory Tract:

Pharyngitis — Bronchitis

Laryngitis — Bronchopneumonia

Nasal discharge — Pulmonary edema

Hoarseness — Dyspnoea
sneezing, cough

Frequency and type of breathing:

Sputum: character

quantity

blood-stained, etc.

(d) Digestive system:

Vomiting — Diarrhea

Abdominal pain

(e) Urinary system:

Lumber pain — Quantity of urine

Character of urine

(f) Circulatory system:

Pulse — Temperature

Venous congestion — Evidence of shock

(g) Nervous system:

Headache — Mental Confusion

Giddiness Convulsions

Depression Coma

Specimens for chemical analysis.

Blister fluid Blood (about 5cc)

Urine (about 6 oz.)

Vomitus (do not pass stomach tube or give emetic.)

Note: It must be understood that these specimens are desirable and may be of importance; but any difficulty in obtaining them should not be allowed to delay the transmission of clinical findings or the treatment of the patient.

HOSPITALS AND GAS

Notes on the Reception and Management of Gas Casualties

I.

Should the enemy use gas, the medical services would inevitably be taxed heavily and the hospitals would be confronted with a variety of new problems, both clinical and administrative. Some of these must remain unforeseen. For others past experience and other sources of information provide a solution. As with bombing, so with gassing, modifications of plan and method in respect of the collection, transport, hospital treatment and evacuation of casualties would evolve from experience derived in new situations. In the meantime it must be considered urgently necessary to establish a state of preparedness in every suitable hospital in the country for such contingencies as can at present be visualized. Such preparedness demands thought and action and training, but need not involve any undue elaboration or expenditure. Much information and instruction has already been issued on decontamination and the treatment of the individual case. Outside the hospitals training and preparation should be now well advanced. The present notes relate to organization within the hospitals.

II.

Medical Officers in Charge of Gas Casualties

In every hospital capable of receiving casualties there should be at least one physician whose duty it would be to take charge of the reception, sorting, and care of gas casualties. From the available manuals and other literature, and attendance at lectures and courses he should make himself acquainted with the essentials of diagnosis and treatment. He should hold himself responsible for the instruction of house officers, nurses, and orderlies and, in the teaching hospitals, of students, in the methods of treatment advocated for casualties due to both the vesicant and pulmonary irritant gases. Where staff is short, the cooperation of dental surgeons for assistance with oxygen therapy could also be sought. In conjunction with the Medical Superintendent or Medical Officer in Charge, he should inspect the arrangement and equipment of the hospital decontamination center. He should personally supervise the training of a decontamination unit (male and female). He should acquaint himself with the storage, source, and reserve supply of oxygen cylinders. He should procure or improvise sets of apparatus for the distribution of oxygen from one cylinder to several patients. He should ensure that all those likely to be concerned understand the use of the nasal catheter, the B.L.B. mask, and the fine adjustment valves and flowmeters, and that there is a sufficient supply of all these and of rubber connection tubing and glass connections.

Wherever conditions permit, intimate records of symptoms, signs and progress and more particularly of new phenomena and thereapeutic improvements should be kept.

III.

Organization

As with wounds so with gas casualties, "reception and management" may be held to cover decisions in relation to (a) the grouping or separation of cases into categories for special treatment; (b) the initial reception and sorting of cases; and (c) the disposal of cases, including suitability and optimum time for transportation elsewhere of special types of cases. Such decisions clearly require different consideration and arrangements in the case of vesicant and pulmonary irritants.

IV.

The Reception and Management of Casualties Due to Vesicant Gases

Although every hospital should have its decontamination center and a trained decontamination unit, it should not be called upon to deal with mildly or moderately contaminated cases given good cooperation on part of the public, the Protection Services and first aid posts and cleansing centers. It should, however, expect to handle (a) severely contaminated cases (liquid) or persons who have recently been exposed in, or in the neighborhood of, the hospital. Of such cases, once decontaminated and in receipt of initial treatment for skin and eyes it should be possible to evacuate the majority as stretcher or sitting cases forthwith or at an early date, except for those whose associated wounds are of such severity as to preclude movement.

During the hours or days following a local gas attack it is probable that other cases than those in the above categories would begin to arrive for treatment of developed lesions. Minor skin and eye cases could be treated as out-patients or, if desirable on other grounds, evacuated. Admission might be necessary for severe or extensive skin lesions. Again, however, the evacuation of most of these, excepting the more severe broncho-pulmonary cases, should generally be justifiable. Cases in the above categories would be in a stage past that in which further decontamination by washing would be necessary, or, in fact, of any value. In the case of persons recently gassed and suffering from wounds and wound-shock, decontamination should not go beyond careful undressing with free use of scissors, attention to exposed parts and initial treatment of the eyes and cutting of obviously contaminated hair if there is reason to assume liquid contamination. Once undressed and so treated patients would no longer present serious dangers to those working in the operating theatres or to other patients or personnel in a ward. Elaborate protective measures for personnel would not be likely to prove necessary after the first or undressing chamber.

PART III

OBSERVATIONS REQUIRED IN CASES OF GASSING

A. OBSERVATIONS REQUIRED IN ALL CASES OF GASSING.

1. A complete clinical record should be kept of all that happens to a patient from the time when he comes under observation until he is out of danger or death occurs. Observations should be recorded at the time they are made and the time accurately noted.

2. So far as possible accurate information should be obtained as to the time and place of exposure to gas, the protection employed from gas-mask or otherwise and the promptness with which it was employed, and the interval elapsing between exposure and admission to hospital.

3. The probable or proven nature of the gas should be noted and particulars ascertained as to its mode of dissemination (shell, bomb, spray).

4. The age, sex, physique and type of the patient should be noted and the date and time of admission.

5. The general physical and mental state of the patient on admission.

6. The temperature, pulse-rate, respiration rate and B. P. should be recorded at four-hourly intervals unless occasion arises to make more frequent observations or the patient has so far improved as to make frequent readings no longer necessary.

7. The occurrence of thirst, nausea, vomiting should be recorded.

8. The fluid intake and urinary output should be carefully recorded and observations made on fluid loss by sweating, etc.

9. The warmth or otherwise of the extremities should be noted.

10. The urine should be examined daily (spec. grav., albumin, sugar, red cells, casts) in the early stages.

11. The nature of the treatments employed and the time of introduction of any special measure of treatment should be entered.

12. In the event of death the manner of death should be described and a detailed pathological report obtained whenever possible.

B. SPECIAL OBSERVATIONS REQUIRED IN CASES OF GASSING WITH PULMONARY IRRITANTS.

1. The colour of the patient on admission (blue or grey cyanosis,

pallor, etc.) Changes in color and relationship to treatment.

2. The presence or absence of overfilling of the neck veins.

3. The type as well as the rate of respirations (shallow, grunting, gasping, expiratory or inspiratory difficulty, etc.)

4. The amount and character of the expectoration over six-hourly periods. In the case of copious serous transudate from the lungs specimens should be kept for analysis and microscopic examination.

5. With as little disturbance to the patient as possible daily observations on the auscultatory lung signs and on the size and sounds of the heart.

6. The methods of oxygen administration, when employed (nasal catheter, B. L. B. mask, etc.) and the rate of administration (litres per minute). At which stage does oxygen (a) become necessary, (b) do most good?

7. Other therapeutic measures employed (venesection, posture, drugs, intravenous fluids).

8. The subjective and objective effects of these methods of treatment, whenever possible avoiding the simultaneous introduction of two or more of them. The effects on pulse rate and quality, systolic and diastolic B.P., the state of the veins in the neck, and color and respiration rate of oxygen, venesection and posture change especially to be noted.

C. SPECIAL OBSERVATIONS REQUIRED IN CASES OF GASSING WITH VESICANTS.

1. The extent, degree and special appearances of the skin lesions on admission and subsequent changes in these. If possible color photographs or paintings, when comparing local treatments. The subjective phenomena and effects of treatment.

2. The time elapsing before and after initial decontamination and the methods of decontamination employed.

3. The local treatments subsequently employed with dates and times of initiation (tannic solutions, sulphonamide, etc.)

4. The character, degree and special appearances of the eye lesions (conjunctivitis, blepharitis, chemosis, corneal opacity or ulceration). The initial treatment employed at time of decontamination and the time of this. Subsequent treatments and times and effects on subjective and objective manifestations of different treatments compared.

5. The degree and extent of respiratory tract lesions (laryngitis, tracheitis, bronchitis and bronchopneumonia). Symptoms and signs and effects of chemotherapy in prevention of secondary infection.

6. In the case of vesicant gases other than "mustard" general and visceral effects, and detailed observations on the blood for evidence of haemolysis etc.

DECONTAMINATION OF CLOTHING, EQUIPMENT AND MATERIALS.

A very essential measure of prophylaxis against injury from mustard gas is the systematic decontamination of all clothing, equipment, materials and other objects contaminated by the gas. Our knowledge of the stability of this vesicant, its penetrative power and its persistent character forces us to realize that all such clothing and materials will be dangerous to wear or to handle until they have been subjected to some process, active or passive, which will ensure either the destruction or the removal of the mustard gas they may contain.

Although the Medical Officer is responsible only for the personal decontamination of individual contaminated casualties (i.e. persons who are both contaminated and sick or injured) who come under his care, it is important that he be familiar with the general principles on which decontamination is based, as the degree of efficacy of a particular process in given circumstances may have a direct bearing on the incidence of mustard gas casulties.

Satisfactory decontamination is essentially a skilled process, hence the personnel employed in carrying it out must be trained for the purpose. Moreover, they must possess a knowledge of chemical warfare substances and their characteristics if they are to make effective use of any anti-gas measure they may adopt. These measures will vary, in the case of mustard gas, according to the material to be decontaminated, the nature and extent of the contamination, and the environment, the process adopted in a particular case being often dependent on local conditions and the facilities available.

DECONTAMINATION OF STRETCHERS.

If the ordinary pattern of stretcher is splashed with liquid mustard gas it is difficult to obtain complete decontamination, since the canvas is fixed to the woodwork by a large number of nails, which renders the removal and replacement of the canvas impracticable under field conditions. It is therefore important to adopt all possible measures to prevent contamination occurring.

Stretchers, when not actually being used, should, therefore, be kept under cover (e.g. indoors or under any improvised roof, tarpaulin, etc.) to prevent them being splashed with liquid blister gas. As an additional precaution the canvas should be covered with a stretcher cover. The stretcher canvas may be protected with an improvised cover of a resistant material such as heavy building paper. Such improvised covers should be destroyed after use.

If, in spite of precautions, contamination does occur, the complete stretcher should be scrubbed with bleach paste and later washed thoroughly with water, after which it should be left to weather as long as possible. The handles may not be safe for contact with the bare hands for several days, but this difficulty can be overcome by wearing anti-gas gloves. Any danger from residual contamination on the canvas can be counteracted by the use of the covers described above.

PREPARATION FOR TREATMENT OF GAS CASES IN A TYPICAL LONDON HOSPITAL

GAS AT GUY'S

SORTING AND RECEPTION OF GAS CASUALTIES

Sorting

Cases will be admitted through the War Memorial Gateway. They will be unloaded in the passage leading to the Eye Ward, where they will be inspected by the Sorting Team, consisting of the Sorting Officer (myself or my deputy); the surgical interne, if his duties permit, two stretcher bearers, all wearing protective clothing. The function of the Sorting Team will be allocate the patients as follows:

1. To the Decontamination Unit. Patients who have been exposed to blister gas vapour or liquid and whose injuries are not so grave as to contra-indicate the vigorous process of cleansing. The Sorting Officer will append labels to these patients as follows:

   (1). "Eyes". These patients will be admitted straight to the Decontamination Unit Reception Room and receive immediate attention from the Eye H.S.

   (2) "Cleansing Priority". These patients will be rushed through to the Cleansing Room and subsequently to the Reception Room or if possible straight to the Eye Ward.

   (3) "Cleansing Routine". These patients will undergo the normal routine of the Reception Room, Cleansing Room and Resuscitation Room and will be admitted in due course to the Eye Ward.

2. To the Eye Ward. Patients whose surgical injuries or shock take precedence over their exposure to blister gas. They will be passed in through the window of the Eye Ward kitchen, relieved of their outer garments and boots and if necessary have their hair rapidly shaved before being admitted to the Ward.

3. To the York Ward. Patients who have been exposed to lung irritants. They will be taken in the Guy's ambulance to the Borough High Street entrance of the York Ward.

4. To the Out-patient Hall. Patients suffering from the effects of tear gas or nasal irritants, or patients in whom there is no clear evidence either of blister gas or lung irritant contamination.

Reception

1. Decontamination Unit

(1) Removal of Outer Garments. As far as possible this should be done outside by 2 undressers in protective clothing. This procedure should be applied only to patients labelled "cleansing routine". If the night is dark, if the weather is cold, or if the blitz is violent, outside undressing should be dispensed with

(2) Reception Room

(i) "Eyes". Cases labelled "eyes" should be taken straight to the Eye H.S. who will irrigate the eyes while 2 undressers remove such garments as possible.

(ii) "Cleansing priority". Undressers will remove only the outer garments and shoes and send the case through to the Cleansing Room immediately.

(iii) "Cleansing Routine". These cases will be undressed as far as possible before being admitted to the Cleansing Room. The Reception Room personnel (all wearing full protective clothing) will consist of 2 outside undressers, the Eye H.S., and 4 inside undressers to deal with "Cleansing Priority" and "Cleansing Routine" cases.

(3) Cleansing Room. Here washing will be undertaken under the supervision of a House Officer by 2 student cleansers and 2 nurse cleansers, assisted by a student eye washer (all in modified protective clothing.)

(4) Resuscitation Room. Warmth, hot drinks, reassurance and first aid is the function of this part of the unit. The first three will be provided by Sister Broome and her nurses. The condition and first aid treatment of the patient will be attended to by the surgeon on call, if available, or his deputy.

2. The Eye Ward.

(1) From the Kitchen. Cases whose surgical condition demands priority will be passed through the window from the Park and dealt with by the H.S. on duty, 2 undressers and a nurse (all in full protective clothing). The outer garments and shoes will be removed and the hair cut short if necessary. Splashes of liquid may need removal and application of anti-gas ointment to the affected skin. The eyes may require irrigation, and if further washing out is desirable a label marked "irrigate eyes" will be affixed to the patient before he is passed through to the ward. Patients received from the kitchen should be placed in beds immediately adjoining the door and screened off.

(2) From the Decontamination Unit. These cases will be treated on their surgical merit. They will be admitted by the door adjoining the central staircase. The inquiries due to their exposure to blister gas will be treated as burns, other than the eye and lung complications, and their wounds will be treated by ordinary surgical methods.

3. The York Ward.

Cases received here will have been exposed to long irritants (phosgene). The more serious cases needing immediate oxygen thereapy will be admitted to the female ward, the less severe cases and cases for observation will be admitted to the male and childrens' ward. (These wards will have been previously evacuated).

4. Out-patient Hall.

Cases which have been brought in through the War Memorial Gateway as suspected gas casualties, but which are considered by the Sorting Officer to have been exposed neither to blister gas nor to long irritants, will be admitted through the Park entrance to the Out-patient Hall and dealt with as necessary.

Labelling of Gas Contaminated Case.

Labels of four different colors have been prepared:

Yellow (for Mustard) - Cases which are to pass through the Gas Decontamination Unit.

Red (for Blood) - Surgical Priority cases for patients whose injuries or general condition demand immediate resuscitation and contra-indicate their passing through the process of gas decontamination.

Blue (for Cyanosis) - Lung Irritant cases.

White - Cases which have probably not been contaminated and which are to be sent to the Out-patient Hall for observation

The first two types of label are divided by two perforated lines into three parts. On each of these three parts is printed the classification of the case, as follows:

Yellow. "Gas Decontamination Unit. Cleansing Routine." Patients whose injuries do not preclude their being submitted to the routine of gas decontamination.
"Gas Decontamination Unit. Cleansing Priority." Patients who are to be submitted to cleansing, but whose injuries or condition demand that resuscitation should not be unduly delayed. These cases will be treated with priority by Outside Undressers and in the Reception and Cleansing Rooms.

"Gas Decontamination Unit. Irrigate Eyes."

Patients whose recent contamination of the eyes either with liquid or with vapour demands immediate irrigation. Irrigation is commenced by the Eye H.S. in the Reception Room and is continued in the Cleansing Room by the Eye Washer.

Red. "Surgical Priority." Patients whose outer clothing and shoes only are to be removed before immediate admission to the ward.

"Surgical Priority." Irrigate both while the outer clothing is being removed and after they reach the ward.

These labels, each of the three parts of which are marked with a serial number, are used in the following way:

Yellow. (Gas Decontamination Unit)

1. The whole label is affixed in the sorting station to the patient's coat.
2. When the outer clothing is removed one portion of the label is torn off and accompanies the discarded bundle of clothing into the decontamination bin. The rest of the label is clipped on to part of the remaining clothing.
3. When the rest of the clothing is removed the second portion of the label is torn off and accompanies the bundle of underclothing into the decontamination bin in the reception room. This bundle is placed in a numbered canvas bag, and a disc bearing the corresponding number is hung round the patient's neck.
4. The remaining portion of the label accompanies the patient to the cleansing room and finally to the resuscitation room.
5. In the resuscitation room a record is kept in a book, showing the patient's name, the number on the label and the number on the disc. This will facilitate the patient regaining his clothing after it has been decontaminated.

Red. (Surgical Priority)

1. The whole label is affixed in the sorting station to the patient's coat.
2. When the outer clothing is removed one portion of the label is torn off and accompanies the discarded bundles of clothing into the decontamination bin. The rest of the label is clipped onto part of the remaining clothing.
3. When the rest of the clothing is removed the second portion of the label is torn off and accompanies the bundles of underclothing into the decontamination bin in the ward.
4. The remaining portion of the label is kept with the rest of the patient's records. The serial number on label will enable the ward sister to identify the patients clothing after it has been decontaminated.

July 1941 ———————— P.M.F. Bishop
Deputy Superintendent

Section IX

The following is a series of articles on gas warfare considered appropriate for newspaper publication.

WAR GASES

No. 1

In this series of articles an attempt will be made to tell you about war gases, what they are, how they act, how injury may be prevented and something about the organization which has been, or is being, set up in your community to protect and care for you if gas is used.

This is especially necessary as the general public is misinformed as to the dangers incident to the use of war gases, and, since we are all part of the "front lines", it is necessary that the true facts be known.

Our military experts tell us that it is unlikely that gas will be used on the civilian population. Despite the increasing range and capacity of aircraft the idea of a gas attack on such a scale as to cause injury to a substantial portion of the population of a large city is regarded as fantastic. Even in limited areas gas, to be highly effective, must be used in great quantities.

Gas might be used in an attack upon a city either alone or in conjunction with other weapons. The better the people are trained and equipped to deal with gas the less likely it is that gas would be used against them.

Quick-acting types of gases may be used against a town or city to produce immediate casualties, throw the population into a state of panic and disrupt their Protective Services. Slow-acting types, which may remain effective for several days in a liquid form, may be used to "contaminate" important factories, railroads, highways, etc. to prevent their use. Such gases could be sprayed or sprinkled from airplanes in the form of a fine rain or they may be contained in bombs dropped from planes.

WAR GASES

No. 2

Some of the war gases are liquids at ordinary temperatures. As evaporation take place the vapors given off may cause injury to those in the neighborhood. Some of the gases may "contaminate" an area for several days or even weeks, depending upon the weather. They will evaporate more rapidly if the weather is hot. Such gases are known as "persistent" gases.

Other war gases are released as vapors or evaporate almost at once. They are quickly acted upon by currents and eddies of air which rapidly break up the gas cloud. Such gases are said to be "non-persistent."

Each group is composed of several members but all war gases have one characteristic in common: So that they will remain close to the ground they are all heavier than air. In addition all the known war gases act either on the skin or the lungs or both.

We have all heard reports about new all-powerful gases against which there would be no protection, or against which our present gas masks would be ineffective.

Such reports are without basis in fact. There are many gases commonly used in industry which are more injurious than any of the known war gases but, for one reason or another, none are suitable for use in the open. Furthermore, our gas mask is a very versatile piece of equipment and it is doubtful if a gas will be developed against which it will prove ineffective.

The soldier in the field cannot leave his post or seek shelter if gas is used against him. To do so would permit the enemy to advance through his lines. The civilian, on the other hand, can, if gas is used, take shelter in such a way as to eliminate most of the danger. Even after contact with gas the exposed person can do a few simple things for himself which will in most instances prevent serious injury if carried out promptly. These procedures will be discussed in a later article in this series.

WAR GASES

No. 3

The "persistent" gases (those which will remain in ("contaminate") an area for a long time) will burn the skin, or injure the lungs or eyes. The two principal members of the group are mustard and lewisite. They will remain in an area for several days or weeks depending on the weather. The presence of gas can usually be detected by its odor. The sense of smell is the best gas detector known.

Mustard gas: The vapors given off by mustard gas smell like garlic or horseradish. The gas can be smelled in very low concentrations, even in concentrations below that capable of producing injury. Of course if one stays in even a very low concentration for a long enough period of time injury may result.

Mustard gas will penetrate any porous material in time. It will be held away from the body by heavy clothing for a short period. The clothing, once it has been penetrated by the gas, is a source of danger because it will hold the gas in intimate contact with the skin.

Even if no steps are taken to neutralize the gas following exposure to mustard vapor it is usually 4 to 6 hours or longer before any discomfort is experienced. The person may then have a sensation of smarting or burning much the same as if he had been sunburned. His eyes will smart, burn, and water as if they had tobacco smoke in them. He may have a mildly sore throat, a nasal discharge and cough, much the same as the symptoms of a common cold. If exposure has been more severe blisters will appear in the "sunburn", the eyes will burn and water more and the "Common cold" will be quite troublesome. If severe injury is sustained all the symptoms will be exaggerated but this should rarely occur if prompt steps are taken upon exposure to mustard gas vapor.

The person may come in contact with liquid mustard either by brushing against an object covered with it or some of the droplets may fall on him during a raid.

Should this occur the injury will be more severe at the point of "contamination" but should not be as extensive as with a vapor burn. Of course if the individual stays in the area he will have a vapor burn as well. Even with liquid mustard there will seldom be any symptoms for one or two hours. A blister usually appears rather promptly after symptoms develop from a liquid injury.

Unless the amount of liquid is very great the burn will be about like that caused by an equal amount of very hot grease. It will take somewhat longer in healing than the grease burn but should cause no greater alarm.

If liquid mustard should get in the eye it will cause serious damage unless it is washed out immediately. Any person who has gotten liquid mustard in his eye after rendering first aid to himself must be seen by a doctor. Obviously injuries by falling droplets of liquid mustard should be few and far between if the individual will remain under cover during a gas attack.

Lewisite is very similar to mustard gas in its action. It smells like geraniums but causes a biting sensation in the nose even in very low concentrations. Symptoms resulting from lewisite injury develop more rapidly than those following exposure to mustard and are of about the same degree of severity. Lewisite contains arsenic, however, and this will cause poisoning if it is absorbed in any amount. Any person having a blister following exposure to lewisite must be seen and cared for by a doctor. The organization of the Emergency Medical Services for the care of gas victims will be described later.

Any person who gets liquid lewisite in his eye must immediately wash his eye and then be seen by a doctor.

WAR GASES

No. 4

The lung irritants:

Most of the lung irritant gases that we know about are "non-persistent" - that is, they are quickly diluted by air to such an extent that they are incapable of causing injury. Chlorine, which has a pungent odor; phosgene, which smells like fresh cut hay; and chlorpicrin, which has a sweetish odor like fly paper, compose this group.

Of the non-persistent gases the one most likely to be used is phosgene. If there is a moderate amount of phosgene in the area, there is often a "catching of the breath" and a sense of tightness in the chest on breathing the gas. Other than this momentary discomfort, the victim may have no symptoms for as long as twenty-four hours. If injury has been mild, there may be some increase in the breathing rate. The injured person becomes drowsy and falls asleep. When he wakes, he feels quite refreshed. He will probably have some tightness in his chest and have a cough.

With more serious injury, the victim will breathe hard in an effort to get more air. A bluish color may creep into his face, first appearing about the lips and gradually spreading.

With the injury caused by the lung irritants, there is an impairment in the ability of the lung to absorb oxygen.

It is therefore necessary that nothing be done to increase the victim's need for oxygen. A person exposed to a lung irritant must be kept at absolute rest - he must not be permitted to get out of bed for twenty-four to forty-eight hours, even if no symptoms develop.

If any symptoms develop, even those indicating only slight injury, the injured person must be cared for by a doctor.

With proper rest and care, such as is available in our modern hospitals, death should seldom occur following exposure to the lung irritant gases. Complete recovery will occur in the vast majority of cases. Research shows that those who recover from the injuries caused by these gases are no more susceptible to pneumonia and tuberculosis than others.

Tear gas and sneeze and vomiting gas are non-persistent agents which may be classed as "Harmless Nuisance Gases." We shall discuss them as a group.

Symptoms come on very promptly after exposure to one of them. Tear gas causes smarting and watering of the eyes, thus interfering with vision. By getting out of the area, facing the wind and holding the eyes open, the symptoms will quickly disappear. Do not rub or bandage the eyes.

Sneeze and vomiting gases cause considerable distress which is always of a temporary nature. Following exposure the nose should be washed out with a solution containing a teaspoonful of baking soda to a glass of luke-warm water. This will neutralize much of the agent and make the victim more comfortable. Severely gassed persons may require a short period of bed rest.

WAR GASES

No. 5

In this article we shall discuss how, by following a few simple rules, injury by war gases may be prevented or modified. If mustard or lewisite are used, the most serious injuries will result from the liquid agent. Therefore, during a raid, remain inside, or go inside if you are outdoors, to prevent the liquid reaching you.

You will recall that we said that the war gases are heavier than air so that they will cling to the ground. You can get away from the vapor, then, by going to the upper floors of a building and by avoiding basements and other low places. Even after the raid it is better that you remain within a building

on the upper floors than that you try to get out of the gas area. You will not know in what direction you should go. It would be better for you to get a little "sun burn" than to run through an area where there was a lot of liquid mustard. Your air-raid warden will guide you to safety when it is safe for you to move.

SELF AID IN A GAS ATTACK

1. Self aid is the best aid for the prevention of injuries due to war gases. War gases are usually not dangerous if you take steps immediately to remove them from the skin and eyes. Effective means to accomplish this are in every kitchen and bathroom.

2. If you are inside a building, remain there and go upstairs, for war gases cling to the ground. Do not leave your house unless it is absolutely necessary. If you are outside and not able to get indoors immediately, walk - don't run - to get out of the gas area. Avoid puddles of liquid agent, basements, valleys and other low places.

3. If you have been exposed to a war gas-

a. Breath through cloths wet with baking soda solution.
b. If you can get inside a building do so, but first remove your outer clothing and leave it outside.
c. Wash your hands and then your face with laundry soap and water.
d. Wash your eyes at once with a large amount of a solution of baking soda; one teaspoonful of baking soda in a glass of water.
e. Take a bath using plenty of laundry soap.
f. Wash your eyes again with baking soda solution.

4. If splashes of liquid gas have gotten on you-

a. Using small pieces of cloth, cleaning tissues or toilet paper blot up as much of the liquid as you can; being careful not to spread it.
b. Daub the contaminated area with clothes wet with Clorox Purex, Sani-Chlor, etc.
c. Steps b, c, and d in 3 above.

5. Never get excited. Lie down and cover yourself with a blanket Medical aid is on the way. There is no immediate serious danger from exposure to any known war gas.

WAR GASES

No. 6

The Anti-Gas Organization in your City-:

The anti-gas organization in your city is divided into two parts.

In association with the casualty stations and hospitals of the Emergency Medical Services, facilities are being developed to remove "persistent" gases from injured people. This is necessary so that they will not carry the gas into the hospital. The average person can "decontaminate" himself as we described in a previous article. These special facilities should be reserved for those who have other injuries as well. The personnel needed to man these stations are now being trained.

As we described, the "persistent" gases may remain in an area for days or weeks making it dangerous. To cope with this situation, decontamination squads have been organized in the Department of Public Works. These squads are equipped with street flushing machines, brooms and special spraying apparatus. They have been or will be furnished with special chemicals which can be used to destroy "contaminating" gases. They are being trained in techniques required for their work.

A senior gas officer should be appointed from one of the established municipal agencies, preferably the Health Department. This man will be responsible for giving technical advise as regards the work of decontamination squads. He will also be responsible for the identification of the gas which has been used and will mark out the gassed area. He will also give technical advice about the care of food and water which may have been exposed to gas. He will supervise the handling of clothing which has been contaminated by persistent gas. He will, of course, select and train others to help him with his work.

Courses have been conducted through the auspices of the War Department Civilian Protection Schools and the Office of Civilian Defense for the training necessary in the various branches of the gas-protection services. While all members of the services have not attended, a sufficient number have now been instructed to act as teachers of others in most of our exposed cities.