June 11, 1919.

To the Dean
Medical Faculty.

Dear Dean,

I have read the thesis submitted by F. R. Brunner for the M.D. degree, "On certain aspects of gas poisoning in War," and I recommend that it be retained.

Yours,

[Signature]
ON CERTAIN ASPECTS OF GAS POISONING IN WAR.

BEING OBSERVATIONS ON TREATMENT.

(EFFECTS.

BACTERIOLOGY.

F.R. BREMNER, MA, S'AND, MB, CM, LRCP, LRCS, EDIN.
General Considerations.

The Spring of 1915 will rank as one of the most memorable periods of this War, for it was at that time that the Germans made the first deliberate attempt in warfare to destroy human life by means of noxious gases. The French were attacked first (on April 22nd), and our own troops on the following two days; the gas then employed by the enemy being chiefly, if not solely, chlorine.

Subsequently, various other gases were from time to time used by them for offensive purposes. Many of these gases resembled one another in the symptoms to which they gave rise, whilst having a selective action on certain organs of the body, and thus producing definite physiological effects.

Types of Gas Irritants.

The gases may be conveniently grouped under four headings:—
(1) Eye irritants (lachrymators); 
(2) Nasal irritants; 
(3) Lung irritants; 
(4) Orificial irritants.

MIXTURES OF GASES SOMETIMES FOUND TO BE EMPLOYED.

Whilst the symptoms in a case of poisoning by a particular kind of gas were generally characteristic enough for diagnosis, it sometimes happened that effects known to be produced by other gases presented themselves at the same time. The inference was that a mixture of gases was being used with the evident intention of deceiving our officers & men as to the nature of the principal gaseous component, and of obtaining thereby a probable military advantage.

Nature of mixtures—exemplified.

Thus, a lachrymatory and a lethal gas in combination might induce the belief in the men that the former gas alone was used, and that, therefore, the wearing of a gas mask was unnecessary, so long as vision was not seriously impaired. However, the practical certainty that such mixtures were being employed for this
purpose was, happily, for our men, detected by our medical officers, with the result that proper precautions were taken.

Mustard Gas — and other gases.

The following remarks refer mainly to cases of Mustard gas poisoning, the gas in question being largely used at the time these Notes were taken by me from personal observation. Symptoms would, however, sometimes point to the possible mixture of gases in some of the cases. A few observations therefore have been made on gases known to produce such symptoms.

Sixty Cases.

Sixty cases were seen at a Base Hospital and fifty-seven of these cases were under my care.

In the Appendix a short note on the chemical properties of each gas discussed is given together with clinical memoranda of the
MUSTARD GAS POISONING.

Mustard gas = symmetrical dichloro-diethyl sulphide.
C₆H₄-S-C₂H₅·Cl. — appearance and smell.

Most of the men could give some description of the gas. "It smelt like mustard," "mustard trees," "it was like the dirty exhaust from a motorcar," "it had a faint garlic odour." etc.

Symptoms.

The patient expressed his symptoms somewhat as follows:

"My eyes were gritty and brimmed up; the throat was dry, parched and burning.
I coughed a great deal, spitting up phlegm.
My chest felt tight and heavy. I was dizzy and vomited. My voice went, and there was burning and itching over my body."

After exposure to mustard gas, a man feels considerable irritation and smarting of the
Lyres, which run with water, & become slightly inflamed. He has headache, epigastric pain, nausea, and sometimes vomiting. Later, he suffers from dryness and burning of the throat, accompanied by a harsh, ineffective cough. The symptoms are soon followed by the appearance of a dark-red rash on the face, neck, & shoulders, also on the back, buttocks, thighs and genitals. Later, blisters usually develop on these areas.

Clinical features of a typical case.

A few hours after a man has been exposed, he presents a characteristic appearance, of which I have had confirmation by its reproduction in the cases of most of my patients in succession. With eyes tightly closed, reddened, and oedematous, the patient lies temporarily blinded. Separation of the lids is usually followed by a gush of tears which flow over his
reddened and blistered face, while there is, at the same time, considerable nasal discharge, and usually, a harsh cough. As a rule, there is much pain in the eyes, and headache is generally severe. The respirations are usually not much quickened at this stage of the illness. Towards the second or third day blisters form over the reddened areas and frequently on the genitals. Bronchitis ensues, and this, in severe cases, is followed by a septic broncho-pneumonia, due to secondary infection of the necrosed tracheal mucous membrane in the respiratory tract.

The gradual onset of cyanosis, with cardiac dilatation, indicates the grave condition of the patient. Death may occur at an early date — during the first few days — or be delayed till the course of the third week in lingering cases.
After-Effects—Mustard Gas Poisoning

Eye.

The lesions were the most frequently observed by me, all the patients being affected to a greater or less degree.

The sensation was that of a gritty feeling, or of a burning and smarting, accompanied with photophobia, pain, and lachrymation.

The more severely gassed cases had profuse lachrymation, marked congestion of the conjunctiva, oedema of the lids, erythema of the skin over the lids, and mucous to mucopurulent discharge.

Nature of lesion—a chemical burn.

The lesion was that of a chemical burn. Frequently the conjunctival vessels were dilated, sinuous, of a bright-red colour. Usually the cornea was unaffected, but occasionally there was a slight hazy appearance just beneath its centre.
One observer noted a condition of blepharitis, with excoriation at the outer canthi.

**Pupils.**

The pupils reacted to light and to accommodation.

**Skin.**

Thirty-two per cent of the cases with which I had to deal showed some skin lesion. This was variable. With some the skin was merely scorched, the erythema being of a scarlatiniform type. Pressure on the skin with the finger produced a blanched area; on withdrawing the pressure the area would flush again quickly and uniformly. There was no purpuriform appearance such as occurs in a similar examination in scarlet fever. In mild cases of mustard gas poisoning, the exposed skin and mucous membrane generally escape.

**Acute congestion, blistering, desquamation.**

In others, again, there was acute...
Congestion, accompanied by blistering and desquamation. One observer saw a case which developed a typical prickly heat with intense itching, five days after he was gassed. This case had previously suffered from prickly heat in India.

Position of the lesions.
The sites most frequently affected were:
1. The face and neck;
2. The back and buttocks;
3. The inner sides of the thighs;
4. The genitals and axillae.

Pigmentation.
Pigmentation was present in many of the cases, the colour varying from a dark-red to a condition resembling Addison's disease. In some of these pigmented areas no blistering was seen.

Desquamation.
Desquamation was very marked in areas subject to irritation or more-
ment, e.g., the neck, the upper portions of the thighs, and the genitals.

**Erythema.**
Areas of erythema occurred sometimes in small patches, or again, extended over large areas.

**Blisters.**
In the centre of these areas blisters of varying size subsequently appeared. When the epidermis separated, healing was usually rapid.

**Vomiting – Cause of.**
Beyond the initial vomiting, there was, generally speaking, very little gastro-intestinal irritation. Possibly vomiting may have been caused by direct irritation of the back of the throat and of the stomach by the gas, or may have resulted from severe attacks of vomiting coughing.

**Appetite.**
Appetite was not much impaired. No case of diarrhoea was observed.

**Pharynx.**
Pharyngitis, to a greater or less degree,
was present in many cases. The faucæ and soft palate were congested, the uvula elongated and retracted. Dyspœsa of the faucæ was followed by a sense of oesophageal constriction. One man had ulceration of the right posterior pillar of the faucæ.

Respiratory System—(1) Nose; (2) Larynx.

About one-third of the passed cases had a varying degree of coryza. One observer noted a case of epistaxis from hyperaemia of the nasal mucous membrane.

Larynx.

Aphonia was the first symptom, coming on generally at once, and sometimes preceded by fits of coughing, usually of a laryngeal type, resembling whooping-cough. In some cases, aphonia was delayed to the fifth or sixth day. The loss of voice, due to laryngeal hyperaemia, continued in many cases for a considerable period. This hyperaemia of the mucous membrane, the result of necrosis, corresponded to
a burn of the second degree. The dry dermis and the cuticular bands were said to be specially affected.

**Phlebozytosis.**

This, when present, was generally dry in character (Case No. 1 had phlebozytosis with effusion). Pain was usually referred to the costal margins, where friction sounds were occasionally heard, as also at the bases of the lungs. Lungs — (Bronchitis; Pneumonia).

About 65% of those under my care showed signs of a bronchial pulmonary irritation, varying from a mild bronchitis to a septic bronchitis and broncho-pneumonia. No case of a massive lobar pneumonia was seen.

**Cough.**

Cough was generally troublesome, and usually worst at night, often ineffective, and expectoration sometimes scanty in amount. The latter was variable in character; e.g., mucous, serous (often watery greenish), copious, frothy, or thick, greenish white, and purulent when
Broncho-pneumonia was present. Violent coughing sometimes produced small haemorrhages from the laryngeal and retro-pharyngeal mucous membrane, with resulting blood-stained sputum, but I saw no condition of this kind among my cases.

Circulatory System - (a) Dyspnoea, cyanosis. Dyspnoea and cyanosis were present in all the graver cases. As a rule, the pulse rate was not increased, the pulse being regular in rate and rhythm.

(b) Bradycardia and Tachycardia. No secondary bradycardia, such as is often found in phlegmon poisoning, was noted. Tachycardia when present, was probably of nervous origin.

c) Myocardium. Dilatation was present in all the fatal cases; in others, an occasional weakening of the heart sounds was noted. No definite "bruits" were heard.

d) The systolic and diastolic blood pressures were usually within normal range.
Hemoglobin and red blood corpuscles.

B. T. MILLER states that the type of gas poisoning and the chemical nature of the gas appear to make no difference in determining the blood changes. He found an increase in the lymphocytes in cases with persistent symptoms: on the other hand, some counts, in moderately severe cases, were either normal or within the limits of error. According to this observer, the cell that is usually increased is the small lymphocyte, this condition being attributable by him to a possible chronic inflammatory change in the respiratory and gastric mucous membranes.

The change in the blood is stated to take several months (three or four) to develop, and may last at least a year.

(f) Blood coagulation.

The blood was stated to coagulate more readily.

Pyrexia.

In 18% of my cases the temperature reached 100°; there was the same percentage where the rise was higher. The
Maximum range was 107 yards.

Nervous system: Beyond headache, transient tachycardia, or a mention of vague shooting pains, this system was not affected.

Urinary system: No albuminuria was found.

**Phosgene Gas Poisoning.**

Phosgene (carbonyl chloride, or oxychloride, &c.). Phosgene is a very powerful lung irritant.

Its effects contrasted with Chlorine: This gas does not excite so much spasm as Chlorine in the upper respiratory passages, and can therefore penetrate more deeply into the lung tissue. Its action is less rapid than that of Chlorine, but it is a more deadly poison, and can cause circulatory failure.

Onset of Pulmonary Oedema delayed. Anomalous characteristic of the gas is the noticeable delay before the onset...
of pulmonary oedema, unless men have been exposed to a strong volume of the gas.

**Symptoms of Phosgene gas poisoning.**

Then exposed to the gas suffer from headache, nausea, pricking and vomiting. There is a sensation of "turning behind the sternum, and the chest feels as if gripped in a vice." The eyes and throat are irritable, breathing is spasmodic, often gasping and laboured, with an accompanying cough. As a rule, muscular weakness is intense: if walking when overcome by the gas, the man stops or sits down. He may even fall prostrate on the ground. Fatal cases are usually those that have been exposed to a strong concentration of the gas. Death from acute pulmonary oedema in such cases is generally very rapid.

**Clinical features — two types.**

Cases show (a) marked or nurses in engorgement, with blue lips; face congested; a full pulse and rapid breathing. In addition, there is usually expectoration of a thin
frothy fluid, often blood-stained. Or, there are observed (b) pale lips, a very rapid and weak pulse, with quick and shallow respirations, and the leaden pallor of collapse.

**Delayed effects frequently fatal.**

Some of our men who had been exposed even to a fairly strong concentration of the gas apparently felt no immediate effects of a serious nature, and "carried on" with their duties, or even marched to their billets until overcome by the poison, which caused fatal collapse within a few hours.

A further case in point was that of an American officer who was exposed to a small quantity of Phosgene gas, following which he experienced no serious effects, and retired for the night. He arose on the following morning, feeling in his usual health, and proceeded to his mess-tent for lunch. When the meal was over, he rose to light a cigarette, fell to the ground, with blood-stained froth flowing from his nostrils and lips;
and, within a few minutes, chiel of acute pulmonary oedema.

Physical signs of pulmonary oedema.

Examination of the chest shows the presence of oedema of the lungs as evidenced by moist rales (frequently of a "bubbling" character), and by bronchitis of the large and small bronchi (sonorous and ribilant phonochi).

The latter, according to my observations, suggestive of asthma, to which, in fact, the condition is closely allied at this stage. (Cases 34, and 49).

Blood pressure changes well marked.

Phosgene is the only gas in which blood pressure changes of any moment are seen. In moved cases frequently have a blood pressure of 140 to 170 (mm.) (systolic) and this is the type which specially benefits by Vernegehin.

The pale and collapsed type may have a systolic blood pressure as low as 100 (mm.) or even less.
DI-PHENYL-CHLOR-ARSINE POISONING.

Di-phenyl-chlor-arsine \((\text{C}_6\text{H}_5)_2\text{AsCl}\)

General Symptoms of poisoning by it.

This gas is a nasal irritant, and gives rise to the following symptoms, viz.: Cough, lacrimation, sneezing, occasionally vomiting, and dizziness. There are also epigastric tenderness, slight conjunctivitis, pharyngitis, and laryngitis. The patient complains of "tightness" in the chest, and of a choking sensation. The voice is husky, and there is burning and irritation of the face. General weakness and fatigue are felt, and men sometimes have transient unconsciousness.

Its effect on the Nervous System.

This gas produces effects similar to Mustard Gas, with, in addition, a definite affection of the Nervous System. Thus headache for several hours was complained of in some cases which had come under observation in an American hospital. The patient had loss of
Muscular coordination, and of the sense of position, weakness of the arms and legs, tottering and shuffling gait, and pain in the legs when walking, but not on pressure over the nerves. The toxasme is believed to act on the central nervous system. Anaesthesia and analgesia, which are stated to be characteristic of poisoning by Chlor-arsine, were observed after an interval of eight to ten days.

Possible source of infection.

Contamination of shell-holes or other battle-area water sources has been suggested as a probable cause of poisoning by this gas; and this seems to me the most likely explanation, for as far as we know, there is no other way in which these symptoms could have been produced.
LACHRYMATORY GAS POISONING.

Lachrymators - Benzy1 and Xy1yl bromides.

Benzy1 bromide. \( \text{C}_6\text{H}_5 \cdot \text{Br} \).

Xy1yl bromide. \( \text{C}_7\text{H}_5\cdot\text{C}_6\text{H}_4\cdot\text{Br} \) (toly1 bromide).

Symptoms.

Though lachrymation is a minor feature of poisoning by gases whose leading symptoms lie in other directions, a lachrymatory gas, properly so-called, gives rise to the following, viz., pain in the eyes, with smarting, and often profuse lachrymation; irritation of the throat, cough, and nausea, vomiting and epigastric pain sometimes occur; and, in strong concentration, this gas may cause pulmonary oedema.

French observations.

M. Achard (1) has named the gases belonging to this group under the heading “Les composés bromures aromatiques,” and he states a number of symptoms caused by them, e.g., sometimes a little epistaxis (exceptionally haemoptysis),
transient loss of consciousness, fever which contrasts with a slow pulse, constipation, headache and backache, retention of urine. He mentions very frequent and persistent anæsthesia, hysterical manifestations, convulsive attacks, with marked clonic movements. One case of hysterical dumbness was mentioned by this observer.

General conclusion regarding Tachyramatory cases. A tachyramatory gas would appear, then, to resemble Di-phenyl-chlor-arsenic in its effects on the Nervous system.
CHLORINE GAS POISONING.

CHLORINE, Cl₂.

A powerful suffocating gas, and lung irritant. An opportunity was afforded me of seeing, in the Spring of 1915, some of the men who were poisoned by this gas. Stored in cylinders in the enemy trenches, it was thrown forward in the form of a cloud, and drifted with the wind.

Symptoms of poisoning—appearance of patient.

The man has severe, continuous and distressing cough, expectoration of frothy sputum, often blood-stained, spasmodic gasping, retching, and vomiting.

His respirations are rapid and shallow, the expression is strained and anxious, and there is marked restlessness. His skin is cold, the temperature sub-normal, and the heart is rapid, with a full pulse.

Headache is often severe, and there is a feeling of intense muscular weakness, the man often describing himself as being "done up." He is cyanosed, his lips and
ears blue, the face flushed and livid, and, in severe poisoning, showing the pale greenish-yellow colour of collapse.

The extraordinary muscles of respiration are brought into play as he endeavours to obtain access of air to the lungs. He lies with head thrown back, or hanging over the edge of the stretcher to help the escape of fluid from the lungs. Frequently he is semi-conscious with muttering delirium.

"Truly awful to behold is the appearance of the strong man poisoned by Chlorine." This remark aptly describes the condition of the unfortunate sufferer.

Dr. Ferdinand Levy (8) gives a vivid description of the appearance presented by some of the French soldiers who were overcome by this gas in 1915. The occupants of the first-line trenches were rapidly asphyxiated. Those who succeeded in reaching the second-line arrived panting, out of breath, more than half-asphyxiated. The condition produced
"was broncho-pneumonia, with threatening of a rapid asphyxia."

Chlorine Gas poisoning - description of typical case.

Dr. Low (8) describes the symptoms in one of his cases thus: -

T - 38 years, 10th Company, in the first-line trenches, was suddenly enveloped in a thick smoke, and experienced almost immediately a feeling of suffocation, severe cough, a sensation of burning in the throat, involuntary flow of tears, headache and vomiting. He stood up with difficulty, his countenance was flushed and cyanosed, and his lips were tinged violet: he breathed with the greatest effort, coughing continuously, with occasional blood-streaked expectoration. From time to time he vomited, the temperature in the axilla was 38.5°, and the pulse very feeble - almost imperceptible - was 145 per minute. Examination of the chest showed the existence of an intense, pulmonary. Perception disclosed no modification of sound, but auscultation
revealed over the upper area of both lungs, in front and behind, some sub-crepitant rales, drowned in sibilences and bronchial spirograms. Physical signs in the lungs.

In the cases which I saw, the percussion note was resonant or but slightly impaired, and the breath sounds were weak posteriorly and at the sides of the chest, with scattered rhonchi and fine rales present.

Jaundice, albuminuria or.

Sargent, (1) Dian (2) and Lees (3) have remarked on the presence of jaundice and renal disorders e.g., scanty urine, and, in some cases, hematuria.

Theories of action of Chlorine.

The presence of albuminuria has been attributed by some writers to the toxic action of the gas on the renal epithelium.

Major Walter Bond in an article on nephritis following chlorine poisoning, says: "It looks as if in some cases the chlorine or bromine damages the lung epithelium so severely that it does not allow absorption into"
"...the general circulation while in others the gas passes through the lungs without affecting them permanently, but then sets up an acute nephritis."

L. Hill (?) does not uphold this view, and maintains that chlorine gas "spends its fury on the lungs" and that the nephritis is due to the intense and prolonged dyspnea and the struggles for breath. He compares such a case with the albuminuria "which one finds as a result of the very temporary dyspnea which athletes suffer in a race," and it is Hill's belief that this albuminuria results from deficiency of oxygen in the kidney, "just as it does when the renal artery is temporarily occluded."

Sir E. Schäfer holds the view that the immediate action of chlorine must be a local one. "For," he writes, "it is scarcely possible to imagine that it can exist in the free state in such a fluid as blood, which contains many bodies with which it would immediately combine, and which would—unless it were introduced in immense quantities—at once render it innocuous."
Linné (2) and Schröer (8) while agreeing that in chlorine poisoning, the bronchial or pulmonary symptoms are the predominating ones, affirm that the toxic product is, in some cases, able to penetrate almost exclusively by the respiratory passages, and to rapidly diffuse through the whole organism by the blood-stream. In support of this view of the action of chlorine gas, they point to the injury to the liver and kidneys that occurs in such cases. The presence of a haemolytic jaundice, of haemoglobin in the urine, of “concentrated urines containing abundant biliary pigment,” and the presence of much albumen, are remarked on in a case of Dujarric de la Rivière’s (8). “Examination of the urine showed an intoxication by bromine and chlorine.” Further, a case of persistent albuminuria in a man poisoned by chlorine, was accompanied by a relapse of Purpura. (He had had three relapses in less than one month). This case was put forward by Sergent and Agnel (1) to illustrate
the toxic action exercised on the blood by chlorine.
The case referred to was seriously ill. He had great dyspnoea, abundant haemoptysis, a sensation of turning over the whole chest, headache, palpitation, general prostration, and local asphyxia of the fingers and toes.

It would seem as if the toxin acted on the central nervous system, producing a condition of marked asthania, and that this may suddenly appear, accompanied by a fall of temperature and by arterial hypotension, with the phenomenon of the 'white line' (Sergeant) suggesting the probability of a suprarenal insufficiency ('syndrome D insuffisance surrenale').

The condition of local asphyxia of the fingers and toes referred to is interesting, a similar condition having been described by two of our British authorities. (3)

They write:

'The man was gassed with chlorine at daybreak, and was in dry trenches, under
"Conditions which could not possibly have induced anything resembling post-bite."

Perry also describes the cardio-vascular syndrome (low blood-pressure and slow pulse) due to the inhalation of Chlorine, the systolic and diastolic pressures being both depressed, and he states that the slow pulse is of toxic origin, and recommends the hypodermic injection of strychnine.

The weight of opinion would appear to favour the theory that it is the deprivation of oxygen, the "air-hunger" of the tissues which is responsible for the later pathological states observed in some cases, especially by the French, e.g., haemolytic jaundice, albuminuria, altered blood states, haematuria, etc. A poison absorbed in the immense quantities necessary, according to Sir E. Schäfer, to produce the pathological states referred to would be quite inconsistent with life for more than a few minutes, in all probability.

Complications in Chlorine poisoning: Generally severe bronchitis sets in, accompanied by much muco-purulent sputum, marked rise in temperature, with rapid respirations and pulse rate. Coma and delirium often precede death.
CHLOROPICRIN GAS POISONING

Symptoms.

On exposure to the gas, a man has vomiting (often severe), pain and a tight feeling in the chest, and abdominal tenderness. There is cough (accompanied usually by a little viscid expectoration,) rapid, generally shallow breathing, and a feeling of suffocation. The gas can cause temporary unconsciousness.

Contrasted with Chlorine, it causes greater sensory irritation of the respiratory passages, and it is a more powerful poison. Although possessing a certain lachrymatory effect, it is, however, not so powerful in this respect as the true lachrymatory gases.
Bacteriology and Morbid Anatomy.

Of all the cases.

Simultaneously with the investigation of each case of which I was in charge, the sputum was examined to determine whether any previous damage had been done to the lung tissue, and to observe the possible predominance of any one particular organism with a view to treatment by serum or vaccine. Thus all the cases were examined for the bacillus of tubercle.

Tubercle bacillus not found.

Investigation of the sputum disclosed no striking feature. No tubercle bacilli were found. The various organisms mentioned, viz., the pneumococcus, pneumo-bacillus (Friedländer), micrococcus catarrhalis, bacillus influenzae, being present to a greater or less degree, and often associated together.

Vincenzi fusiform bacillus found.

In a few cases Vincenzi's fusiform bacillus was found.
Pathological condition found in the trachea and tubes.

The condition pathologically I found was one of extensive mechanical damage to the lining membrane of the trachea and larger bronchial tubes, which were purple and congested, the tubes in most cases being full of pus. The intensely irritating action of Mustard Gas had caused a necrosis of the mucous membrane in the upper and sometimes in the lower air-passages. The larynx was usually edematous, and occasionally showed an extensive membrane over its surface. False membrane occasionally present on the trachea.

In a few cases a membranous exudate was seen on the trachea; usually it extended for a short distance down the posterior wall and then ceased, to reappear at the lower end and spread from there to the bronchi. The membrane did not wash off in a stream of water but was pulled off with difficulty, and on examination was found to contain numerous Vincent's fusiform organisms.
Purulent secretion usually found in the trachea tubes.

The anterior and lateral walls of the trachea were usually free from this membrane, but greatly congested. In the majority of cases I observed no membranous formation, only purulent secretion. In many of them there occurred separation of the thickened and inflamed lining of the larger tubes from the infiltrated deeper tissues.

Post-mortem appearance of the trachea in chlorine poisons.

Major Gen. Sir J.R. Bradford and Capt. J.R. Elliott (3) have published a Note of the post-mortem appearances in the trachea of a patient who died thirty-six hours after having been gassed by Chlorine.

"The man was deeply cyanosed, and lightly delirious. In the actual specimen the most striking feature was the abrupt line of transition from the purple plum-coloured mucous membrane of the upper pharynx to the healthy pinkish-white tint of the unaffected oesophagus at the level of the"
thyroid cartilage. All the surfaces over
which the irritant gas played were
deeply injected and discoloured."

There was however, very little oedema in
the trachea and no inflammatory membranes
had been formed. The laryngeal aperture,
curiously enough, was in most cases free
from oedema and irritation; the voice
rarely became hoarse, and the dyspnœa,
at any rate after the first few hours, was
never caused by laryngeal obstruction.

Pathological condition in the Lungs—Mustard Gaspois?

In the lungs the condition I invariably
remarked was that of a septic inflammation
of the smaller bronchioles with much diffuse
broncho-pneumonia. The bronchioles were
much dilated, and many of them contained
thick yellow pus. There were signs of an
early dry pleurisy, and of sub-pleural
petechiae. In addition, there was marked
oedema of the lung, but no large massive
consolidation.
Pathological condition - Heart, liver, etc.

The heart was slightly dilated in my fatal cases. The spleen was usually congested. The liver showed no abnormal change, but the naked-eye appearances of fatty infiltration are stated to be common, and the organ often enlarged and congested. The stomach occasionally, in my cases, showed signs of an acute congestion, and the presence of sub-acute haemorrhages.

Differential diagnosis - Mustard and Phosgene.

The diagnosis, in a typical case of Mustard gas poisoning, is easy. When however, Phosgene was used in combination with this gas, symptoms would overlap one another. In such cases I came to the conclusion that the condition found on examining the chest would often prove of assistance in determining the nature of the case. The following tabular account of the leading chest conditions indicates briefly what was noted by others and myself on
<table>
<thead>
<tr>
<th><strong>MUSTARD</strong></th>
<th><strong>PHOSGENE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LUNGS.</strong> No signs in early stages; more a few rhonchi present.</td>
<td>Sibilant rhonchi; more commonly &quot;bubbling&quot; respirations.</td>
</tr>
<tr>
<td><strong>SPUTUM.</strong> Very rare.</td>
<td>Abundant, frothy, may pour from the mouth when coughing.</td>
</tr>
<tr>
<td><strong>COLLAPSE.</strong> Rare.</td>
<td>To a greater or lesser degree.</td>
</tr>
<tr>
<td><strong>CYANOSIS.</strong> Rare.</td>
<td>Present.</td>
</tr>
<tr>
<td><strong>BLOOD.</strong> Rare, not common.</td>
<td>Raised.</td>
</tr>
<tr>
<td><strong>PULMONARY OEDEMA.</strong> Primary oedema not common.</td>
<td>Rapidly established.</td>
</tr>
<tr>
<td><strong>PROGNOSIS.</strong> A tendency to septic bronchitis and broncho-pneumonia, due to extension downwards from the bronchioles.</td>
<td>May improve after tracheotomy or oxygen, and when expectoration is fully established.</td>
</tr>
</tbody>
</table>
Prognosis.

The mortality naturally varies according to the nature of the case, and to other factors, and has been estimated at about 5% from the front line to the Base during any one month. In one convoy of serious cases at a Casualty Clearing Station the mortality reached 20%.

Grave cases.

The prognosis is grave in men over 40 years of age, and in those showing evidence of arthritis, or who previously have had pulmonary tuberculosis.

Unfavourable symptoms.

These are:

1. Considerable rise in temperature.
2. A sudden fall in temperature, with increased pulse rate.
3. Increased pulse rate, associated with slight delirium and diminished expectoration.

Symptoms towards the end in fatal cases.

A gradually weakening voice, very husky, and the rattling of mucus as the propulsive power of the diaphragm diminishes, mark
The approaching fatal termination.

Progress in eye cases good.

Although photophobia and irritable weakness may persist for several weeks after recovery, the prognosis would appear, on the whole, to be good; and, except in a few cases, no permanent damage to the eyes seems probable. The skin lesions in serious cases take many weeks to heal.

Prophylaxis - Causes of casualties:

The box-respirator is a complete protection.
for the eyes and lungs, and casualties, when they arise, are due to several causes viz.,
1) Leakage.
2) Removal or absence of the respirator, owing to inability to see through the "goggles" on account of wet weather, or the impossibility (to stretcher-bearers) of placing a loaded stretcher on ground exposed to shell-fire in order to adjust the respirators.
3) Men are often taken unawares by "surprise attacks" of gas shelling.
4) Lack of precautions in entering "dug-outs" or pill-boxes into which poisonous gases may have drifted.
5) Failure to awaken sleeping men.

Warning of danger.
The only warning guide is the sense of smell, and this may often be so slight as to throw the men off their guard.

Protection used in "dug-outs.
The protection used in "dug-outs" is usually that of sprinkling the floor with bleaching powder (when that can be procured), and by "blanketing" of the entrances. These methods are usually
quite effective.

Treatment of Mustard Gas Cases.

Stim.

On admission, clothing was removed as soon as possible, the skin was washed with soap and water, and then bathed with a weak solution, 2% of bicarbonate of soda, which was allowed to dry on the patient. The purpose of this was to remove any poison retained by the grease on the skin, and thus rid of the infection. Mustard gas being slowly decomposed by alkaline solutions.

Blisters.

These, when present, were opened and dressed with lint soaked in a weak solution of picric acid, the excess of solution being wrung out before application of the dressing. This treatment I found gave very satisfactory results; the burns healing up very quickly. Moreover, I noted that dressings could be left for two days, often longer, with good results. This was an additional advantage,
especially when there were numerous patients to attend to.

Suggested treatment for Erythema.
It has been suggested that dry bicarbonate of soda should be used in Erythema of the skin as the liability to subsequent blistering is stated to be less than when a solution of soda is used. This seems quite what would be expected from the soothing and neutralizing effects of the alkali on acid products. I certainly found it efficacious in these cases.

Treatment when skin largely infected.
When considerable skin infection was present, I noted the beneficial results obtained with wet boracic dressings, and the subsequent application of zinc ointment. Slight burns were said to heal well under Lassar's paste containing a small percentage of salicylic acid, but I did not use this treatment.

Treatment of Mustard Gas Cases by the French.

Special arrangements were made at the French Field Ambulances for the treatment
Their cases, viz., the men were stripped, naked, and drenched with a solution of bicarbonate of soda. Cases unable to stand were treated lying on a stretcher. Sometimes the body was scrubbed with soap and warm water in place of the soda solution. Thereafter, the body was dried, the men clothed and allowed to rest. The clothes were hung on ropes in the open air for two or three days and beaten with the object of getting rid of the gas which clings to any article on which it falls, thus becoming a source of danger. Alternately, they were soaked in a solution of bicarbonate of soda.

Reason for soap and water and bicarbonate of soda treatment. (Both for men and clothes.) Grease is removed, the alkali (soap or soda) acting partly by decomposing the substance, and partly by neutralising any acid decomposition product formed. Hence its soothing effect. (This latter I found was marked, and strongly advocated it, having it carried out in all the cases with which I had to do.)
Even employed in handling the clothes were protected by double waterproof gloves, as the gas would penetrate one layer. All these methods of treatment are in my opinion, good. The "beating" of the clothes more quickly assists in freeing them from the gas than when they are simply "hung out," while the labour of drying them if "soaked" is saved.

Protection of the hands is also a very wise precaution, as orderlies are often burnt by the gas through omission to take the necessary care. An orderly who had handled clothes on the previous day at a hospital felt a burning sensation on the hand, which was red and inflamed.

He washed the part with an alcoholic solution of Caustic potash, and the skin was normal next morning.

Eyes.

With regard to our British treatment of the eyes the usual procedure adopted was as follows:

Irrigation several times daily with a weak warm solution of bicarbonate of
Soda, followed by a drop of liquid paraffin placed inside the lower eyelid. This, in my cases, I found very beneficial. At first I used castor-oil after irrigation of the eyes, but later on discarded it as I found it to be more irritating to the eyes than the paraffin. With the view of rapidly reducing, if possible, the swelling of the conjunctivae and eyelids, chloride of calcium has been recommended as an antidote, 10 to 20 c.c.s to be injected subcutaneously thrice during the first day.

I tried this treatment, but discontinued it, as it did not seem to do much, if any good. Further, a medical officer who tried it reported that a large swelling formed at the seat of injection. This pointed to needless suffering.

Eyes - muco-purulent discharge.

When there was much muco-purulent discharge, I applied a 2% solution of argyrol to the palpebral conjunctivae; and this treatment always rapidly improved the condition.
the condition.

Lotion for Subacute inflammation.
After the acute inflammation had passed, a few drops of the following solution were placed in the eyes once daily:

- Boric acid gns.10.
- Zinc sulphate gns.2.
- Water to one ounce.

This, I found, was of great benefit to the patient.

Shades.
The eyes were not bandaged, but protected from the light, and shades made from blue paper, several layers thick, acted well in this respect. Any bluish-grey or greenish-grey shades of paper are equally suitable.

Treatment of Cough.
In the milder forms of Mustard Gas poisoning, and also in cases of irritation of the upper respiratory passages by lacrimal or gas vapour, Cough was frequently troublesome, and often ineffective. In treating this symptom I used, at first, in some of the cases, inhalation of the
vapours from Tinct. Benz. Co., and, in other cases, the following spray:

Peppermint gr. 10.
Olive oil to one ounce.

These treatments relieved, to a certain extent, the cough — which was frequently laryngeal in character. Of the two methods, the latter seemed to give the better result in the cases of my patients.

Creosote, Chloroform, and Oil of Eucalyptus beneficial.

As a further possible remedy for cough, I finally employed a mixture of Creosote, Chloroform and Oil of Eucalyptus, adding a few drops to a pledge of cotton-wool placed inside a perforated zinc mask. The latter was then applied to the face, the upper end of the mask lying over the eye shades, with the object of lessening irritation to the eyes by the vapour. All the men who had had this treatment said they were much benefited by it, and they became very fond of their masks. I noticed that their attacks of coughing were neither so frequent nor so prolonged.

Creosote, being a coal tar product, owes
its disinfectant and antiseptic action to the fact that it is a protoplasmic poison, and I have found it valuable with cases of gassing in many ways. The slight local anaesthetic action which it possesses appeared to act beneficially in some of my cases where cough was not accompanied by expectoration.

Menthol and Tinct. Benz. Co. recommended. The vapour from a mixture of Menthol and Tinct. Benz. Co. was used and recommended by one observer as being of greater benefit than the latter when used alone. I did not try this mixture, having found the "mask" treatment so satisfactory.

Expectorants for pain in the chest.

When expectoration was well-established, a mild expectorant, such as a mixture containing Ammonium Carbonate, Specrantha, and Squills, given several times daily, appeared to relieve the "tightness" in the chest complained of.

Pharyngitis.

In treating this condition I used a warm weak alkaline spray of bicarbonate of
Soda with good results.

**Headache.**

This was relieved by inhalation of Menthol vapour.

**Vineæctomy in Gas Poisoning.**

*Vineæctomy in Mustard gas.*

Though observers (p.57) have recommended vineæctomy for both "Irritating" and "Asphyxiating" gases (the 2 classes into which they divide all the gases used), I found it to be rarely indicated in true cases of Mustard Gas poisoning, although it seemed to me to be occasionally useful in the small number of cases where early cyanosis was present. Probably much of the difficulty in satisfactorily treating all cases lies in the fact that mixtures of gases were employed.

**Vineæctomy in Chlorine and Phosgene Gases.**

This, however, is the greatest benefit in Chlorine and Phosgene gas poisoning, with a blood pressure (systolic) of 140 to 170 mm. One of my cases, poisoned by Chlorine in...
1915, was viresected—unfortunately, however, with only temporary benefit.

Viresected Cases.

Cpt. A. S. Hobbs, Thwaite, (7) has published a series of cases poisoned by chlorine gas in 1915, and viresected by him. They are very interesting reading, as showing
(a) The beneficial effects of viresection.
(b) The necessity for the operation at the earliest possible moment.

The patients were stated to have been "in a condition requiring more drastic treatment than the mere inhalation of ammonia or injection of atropine."

Type of case suitable for viresection.

Of the cases viresected by this medical officer, only those that were cyanosed, with much distress but with good pulse, were bleed. There were two types:
1) Cases with marked cyanosis and dyspnoea, but with a strong pulse.
2) Cases showing cardiac failure, with pallor and collapse. These latter were not bleed. Thus, of a series of ten cases treated at a Casualty Clearing Station,
all of which were cyanosed and equally distressed, five were resected and recovered without further treatment; of the remaining five, two died within twelve hours, and three became livid and more distressed within twelve hours, and resection was done then. These three required cardiac stimulants after bleeding. The blood in all the cases was dark and coagulated easily, and in no case was any odour of Chlorine given off from the blood withdrawn.

The beneficial results were expressed by the patients thus:

Felt easier; chest and head were much relieved, and my breathing was improved; and again, "Felt grand, relieved headache, and eyes, and slept the whole afternoon after it."
irritant gas - Chlorine or Phosgene - on the lung tissue produces an acute pulmonary oedema. This "drowning" of the lung being due to the transudation of blood - serum into the alveoli and the interstitial tissue of the lung, pneumectomy probably causes a flow of fluid from an area where it is in excess viz., in the water-logged lung, to the area depleted of blood." By reason of the inflammation in the lung alveoli, the heart tends to weaken from overstrain in working against an increased pressure through the pulmonary system. The withdrawal of fluid from the lung tissue would lead to lessened resistance through this system. Beneficial effects of Pneumectomy. Pneumectomy is to be recommended for the following reasons, viz.,

1) Cyanosis is much relieved.
2) Congestion in the lungs is lessened, the patient breathing more easily.
3) The nervous system is quietened, headache is relieved, and sleep made possible.
Sir E. Schäfer on Ovexection.

Sir E. Schäfer, in a letter to the British Medical Journal (May 27, 1916) suggested Ovexection, and pointed out that the fatal effects in chlorine poisoning being due to obstruction in the pulmonary circulation, and to oedema of the lung tissue, copious blood-letting seemed "the only remedy which could be expected to produce any immediate effect, if it could be applied soon enough."

Ovexection in Collapsed Cases.

In collapsed cases, with a poor pulse, it has generally been considered harmful to ovexect. I have not seen any such (collapsed re) cases in which this was done, nor have I any details of results.

Dinslaken, however, in discussing a case of suprarenal oedema of the lung in Bright's disease, regards bleeding as the urgent indication, even in collapsed cases. He says: "In spite of the coldness of the patient and the threatening collapse, which would at first appear as contra-indications, there must be no delay, and, without losing an instant, ten to fifteen ounces of blood"
must be withdrawn. The marvellous results of bleeding must be seen to make its importance clear."

In this particular case, which was under his care, Disulaphy states:

The effect of bleeding was immediate. On admission, the death of the patient appeared imminent. Pale face, dull eyes, livid lips, bluish fingers and nails, hurried breathing, wretched pulse—such was the condition of the moribund patient. Both lungs were full of subcrepitant râles.

At first sight, the condition recalled Capillary bronchitis, suffusive catarrh, or acute phthisis. He brought up abundant frothy sputum of a rosy colour. The eyelids were puffy, the legs slightly oedematous, the temperature subnormal, and the urine very albuminous. The oedema pointed to nephritis; the characteristic expectoration and the fine râles in the lungs indicated suppurative oedema.

The patient was cupped, and ten ounces of blood drawn off. In less than an hour the breathing was easier, the expectoration was less profuse, the fine râles disappeared from
The upper parts of the lungs, and death was averted. In a few days the situation had totally changed: respiration became regular, except that some rales persisted at the bases of the lungs. The urine amounted to fifty ounces (it was eight ounces on the day of admission and markedly albuminous), although albumen was still present.

It is reasonable to believe that peeches would be an efficient substitute for Ninexetin, provided they could be obtained readily and in sufficient numbers.

The French Medical Services quickly recognized the urgent call for Ninexetin in serious cases of Chlorine poisoning, insisting that it should be done at the earliest possible moment and at the Advance Dressing Station when practicable.

Ninexetin in Phosgene poisoning.

The need for bleeding in cases of Phosgene as a measure likely to diminish the amount of fluid sucked into the lungs has been pointed out both by our British Authorities and by the French.
French use of Oxygen.

In addition to the use of Oxygen in the ordinary manner, the French gave it subcutaneously, apparently with advantage. This is contrary to the British view, Oxygen being regarded as useless when given in this manner.

Oxygen—ordinary inhalation—was also given in the Italian theatre of war for both “irritatory” and “asphyxiating” gas.

Benefits from Oxygen.

Usually Oxygen lessens Cyanosis, thereby improving the patient’s chance of life. It is necessary to give it in high concentration and frequently during both day and night at regular intervals. When we consider the whole question carefully, we see that it is the deeply cyanosed cases whether of the congestive or pallid type that call for its administration.

Deficiency of Oxygen in the blood means an increase in the percentage of carbonic acid, and other acids (such as lactic), which appear in the suffocative condition, and
The administration of Oxygen holds these acids in check.

Treatment — Italian War area.

In the Italian theatre of war, observers classifying the gases broadly as "asphyxiating," and "irritatory," (the eyes and mucous membrane of the nose and throat being affected — the name given being probably the equivalent of our term "lachrymatory") obtained good results with the following treatment for both kinds of the above-named gases:

Oxygen and Alcohol vapour, also infusion of physiological saline and simultaneous enoxation were employed. Camphor and Cochine were used to temporarily allay the cough. In addition, atropine was injected. This treatment is said to allay the objective symptoms — moreover, the patient felt better.

This treatment is similar to that adopted by some of our medical officers in Chlorine gas poisoning, excepting in the use of Alcohol vapour which I have not heard of as having been employed.
Ozone treatment.

Major Stoker (B.M. Journal, March 1918)

Recommends Ozone, generated by silica tubes from atmospheric air. Its effects were as follows:

1. Powerful in forming oxyhaemoglobin (especially useful in sinus cases);

2. Complete germicide — used for this greatly in Belgium. Wound discharges and sputum are rendered microscopically aseptic.

3. Strong Cardiac stimulant.

The apparatus used is simple, light, portable. It can be worked with a motor air-pump where there is an electric-light current — or otherwise, with an air reservoir. There is also the advantage of economy and convenience (no cylinders of oxygen are necessary) of (2). I would remark that this has been confirmed to my knowledge; but that the advantages of this treatment may be paid for by subsequent depression.

Insufflation of Oxygen

D. Chassévaud (Daily Review, Foreign Press, 1918)

Says regarding Oxygen that it is necessary to insufflate the gas on the lines of
D'Arcoumall's treatment of Carbon monoxide intoxication by means of an india-rubber catheter introduced far back into the buccal cavity, directly, connected with the compressed oxygen cylinder. Rhythmic insufflation (15 to the minute) is brought about with a regulator key.

Chassécoeurt observes:

"This is a true mecano-therapy of the lung, and renders the painful effort of inspiration unnecessary."

If this treatment I may state that I have found that Oxygen properly administered, — (and perhaps Ozone, if administered with due precautions) — is very similar in its effects.

**Drugs employed in Gas poisoning.**

**Atropine.**

This drug was recommended for use in cases of pulmonary oedema on the theory that it might check the secretion of fluid and dilate the bronchial tubes. I did not try it in any of my cases, and think...
that it would be of no service in those seriously ill. The British and French views are not conclusive as regards its benefit. A disadvantage attending its use is that it may quicken the heart's action.

Sceauanha.

This I found useful in cases where there was scanty secretion, with much purposeless cough, giving it in moderate doses and generally in combination with Ammonium Carbamate. This treatment was often combined with the "mask" method previously discussed.

Ammonium Carbamate.

In moderate doses this proved a most useful drug, as it did not appear to upset the stomach, while easing the "tightness" and "heaviness" in the chest complained of so frequently. This "tightness" of the chest I was always anxious to rid the patient of, as (1) being a source of painful or distressing discomfort to them (2) having a lowering tendency on their general tone — thus retarding their progress.
Digitalis.

In treating the chlorine cases of 1915, I gave this drug in combination with Spermacoeca and Carbamate of ammonia, but I am unable to state positively if it helped the general condition of the patient, and if its omission would have been a disadvantage. The mixture, however, did much good in all my cases that were not too seriously ill, and I was gratified to find, at a later period, that this treatment had given a similar amount of satisfaction after trial at various Casualty Clearing Stations. I therefore think it probable that digitalis was of service in the treatment.

Opium.

Given as Tinct. Opia, or hypodermically, it has been recommended in cases where mental distress was more marked than respiratory distress. I did not use it in my cases.

Camphorated oil, Caffein, Ether, &c.

A mixture of Camphor, Ether and olive oil, hypodermically, has been used both by us and the French as probably beneficial in cases of collapse. Caffeine also has...
proved of benefit with some medical officers who have used it.

**(Strychnine, Spartheine.)**

I found strychnine of benefit in some cases of Mustard Gas poisoning in which the heart's action seemed to be temporarily weak, although the heart muscle itself appeared to be healthy. I have not used Spartheine, nor seen any account of its use by the British. The French appear to employ it occasionally, in place, probably, of digitalis.

**(Bolladoma.)**

This drug has been occasionally employed in cases of capricious cough, but I have not used it in any of my cases. The French speak well of it, however, when used in combination with inhalation of Eucalyptus.

**(Brandy and water.)**

This appeared to do much good when administered in a few doses to cases of moderate severity that felt exhausted and "done in," and when there appeared a likelihood of a temporary collapse. It was given also in the very serious cases.
Pituitary Extract.
Pituitary extract has been given, with much benefit in some cases, as a cardiac stimulant. Administered hypodermically, it acts very quickly.

Sodium Bicarbonate.
In addition to its marked benefit in mustard gas burns, it relieved epigastric pain.
Rest, warmth, and plenty of fresh air.
These are three of the most important factors in treatment.

Methods for aiding discharge from the Lungs.
Ammonium Carbonate.
This drug has been employed by some medical officers in large doses as an emetic, but has been proved to be sometimes harmful, and seems to be of no benefit in the later stages of gas poisoning.
Moreover, the effort often necessary to induce vomiting is exhausting. The French speak, however, of its "enormous benefit" in some instances.
Salt + water.
One tablespoonful or more to a pint of tepid water has been said to be beneficial; tepid water alone has sometimes given good results.

Artificial respiration—Schäfer's method.
This method has been successful in at least one severe case.

Senna enema, warm milk, warm milk and water.

The above-named methods were advocated by the French, especially the giving of warm milk.

The above-named methods of treatment are mainly in reference to cases of poisoning by chlorine. Drugs used in large doses with the object of expelling fluid from the lungs should be used indiscriminately, for they are apt to excite irritant cough, and to interfere with sleep. Further, they may tend to aid disruption emphysema of the lungs, which is especially prone to occur in chlorine poisoning.
SUMMARY OF CONCLUSIONS.

We have seen that noxious gases, whether inhaled or acting directly on the body, produce various clinical manifestations, and that the effects on the tissues caused by them vary in intensity according to several factors, viz.,

(1) Nature of the gas.
(2) Degree of concentration.
(3) Duration of exposure.

We have been mainly concerned in discussing two types of poisonous gases, viz.,

(1) Lung Irritants, (2) Noxics (blistering gases).

In the former class we have Chlorine and Phosgene, and in the latter, Mustard Gas.

I. LUNG IRRITANTS. — Main action.

Dealing firstly with the Lung Irritants, we have seen that this type of gas produces the same pathological effect, that is to say, it damages the alveoli of the lung, and this is followed by the rapid onset of pulmonary edema. Accumulation of fluid in the lung, by interfering with the respiratory exchange, constitutes the immediate danger to
Although irritant gases attack the whole respiratorv tree, as it were, their action is mainly in the deeper respiratory passages, the inflammation extending to the finest bronchial branchings.

Broadly speaking, we have two classes of symptoms in Chlorine gas poisoning, (A) Local. (B) General or Toxic.

(A) Local Symptoms.
There may be subdivided into three categories, (1) Mild. (2) Acute. (3) Intense.
The main clinical features of each class respectively may be stated thus:—
(1) Slight lacrimation, sneezing, cough, with, probably, a little dyspnœa.
(2) Vomiting, tongue covered with a brown fur, breathing rapid and shallow, pulse full, sputum mucous-purulent, and often blood-stained.
(3) Violent bouts of coughing and vomiting.
a feeling of choking and intense suffocation, and severe haemoptysis. "The men die, vomiting abundance of blood and their urine are tinged with blood."

(B) General or Toxic Symptoms.
We have seen that the further effects of chlorine poisoning are manifested on the Central Nervous System, producing a condition of marked Asthenia, the symptoms of which comprise Cough, headache, palpitation, vertigo, and profound lassitude. A condition of local asphyxia of the fingers and toes has been mentioned in connexion with this state.

II. VESICANTS — main action.
It was pointed out that the main pathological condition in MUSTARD GAS poisoning was one of extensive mechanical damage to the lining membrane of the trachea and upper respiratory passages, and, recalling some of the main symptoms of which the patient complained, this pathological condition might reasonably be looked for. The toxins of MUSTARD GAS then, set up
A Cause. Tracheo-Bronchitis, the parts being affected usually in the following order, viz., (1) Larynx, (2) Pharynx, (3) Trachea, (4) Bronchi.

We will be better enabled, perhaps, to draw an analogy between the two types of gases. (Spiritual and Vicaious) if we follow the subdivision in Mustard Gas Cases which has been adopted in dealing with Chlorine, viz.,

1. Mild.
2. Acute.
3. Intense.

The clinical features of each class respectively may be similarly stated.

(1) Ex.- Case 51. Cough with slight expectoration, pain in throat and chest, and blister (right buttock and left thigh).

(2) Ex.- Case 24. Lachrymation, headache, vomiting, dryness of throat, erythema (forehead, neck), lower portion of right thigh, etc. Hypoemia.

(3) Ex.- Case 47. On admission he had severe headache, marked lachrymation, acute pvulent conjunctivitis, severe pharyngitis and laryngitis, bronchitis, and broncho-pneumonia.
Prognosis in (2) — Chlorine and Mustard Gases.

Chlorine Gas.
The prognosis in this class of case is often fairly good, if the patient survive the early stage.

Mustard Gas.
Similarly, the prognosis is very good here, for as we have seen, oedema of the lungs with asphyxial symptoms is characteristic of the early stage in Chlorine and Phosgene poisoning, whereas bronchitis and broncho-pneumonia (and, sometimes, pneumonic consolidation), mark the later stages. The chances, then, of a man’s recovery depend largely on his powers of resistance, his age, the extent of the toxicemia, etc.

Similarly, in Mustard Gas poisoning, a mild Tracheo-Bronchitis does not endanger life, although this condition may last several weeks, with considerable tenderness of the trachea and much pain behind the sternum. The chances of recovery, then, are good.
CHLORINE AND MUSTARD GASES—CONTRASTED.

We see, then, that Chlorine gas kills the patient rapidly, even suddenly, by "drowning" his lungs in edema fluid, whereas in Mustard gas poisoning, the patient dies at a later date from a septic broncho-pneumonia due, usually, to secondary infection of the necrosed area in the upper respiratory passages, or to the formation in the bronchi of numerous foci of pus which has gravitated from the tracheal "false membrane."

The late signs and symptoms to which, as we saw, PHOSGENE gas gave rise do, however, also follow MUSTARD GAS, although the lung edema, in the latter case, does not, as a rule, seriously endanger life. Death may take place, in some cases from Asphyxia, due to blockage of the tubes by sloughs from the bronchi.

Treatment—Results of.
The great majority of my Mustard Gas cases were, fortunately, not of a very
Severe character, and the various treatments adopted were, generally speaking, beneficial. In the Cases that were received in a seriously ill condition, their general state gave little hope of recovery. The treatment for them was symptomatic, and, in all the Cases, disappointing. Their deaths were due, probably to one or a combination of the following causes, viz.,

Age.

Constitution.

Severe toxemia.

With regard to the Chlorine Gas Cases, these were generally evacuated from the Clearing Station within forty-eight hours from admission, and so no record of their progress could be kept, but, as has been mentioned regarding them, their general condition was satisfactory, and encouraging under the treatment that was followed in their case.

Masks in Gas poisoning.

As has been pointed out in Prophylaxis (p. 39), the box respirator is a complete protection.
for the eyes and lungs. Previous to its introduction, temporary protective measures were quickly improvised both by the French and British after the first gas attacks in 1915. The method employed by the French.

The mask used by the French troops was simple and practical. It consisted of a small rectangular bag of fine gauge, several layers in thickness, dipped in a glycerinated solution of hypochlorite of soda. To the four corners of the bag tapes were fastened, one tape passing above each ear, the remaining two being fastened behind the neck. The eyes were protected by special spectacles, strongly made.

Our first protective measure was of a similar nature to the method adopted by the French. Later, a helmet made of flannelette, which completely covered the head. A piece of gauze served as an eyepiece. Disadvantage of the helmet mask.

This mask was an improvement on the first protective measure, but it was uncomfortable for the soldier; it was easily damaged, and
Consequently, rendered useless.

The third type was an improvement on No. 2 pattern, and consisted of a helmet having two glass eyepieces and a valve for breathing out of.

Disadvantages of Masks & Helmets.

1. Breathing in and out through flannelette.
2. Eyepieces became loose or smeared.
3. Air inside helmet rapidly became "stuffy."

Cortini regarded masks as useless, and held the view that more benefit could be obtained by smearing the exposed portions of the body with vegetable oils. He recommended also the wearing of "impermeable" clothes, and the use of goggles with "side pieces."
BACTERIOLOGY.

The following organisms have been already mentioned as having been present in the sputa examined, and the percentage in each case is stated, viz.,

<table>
<thead>
<tr>
<th>Organism</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micrococcus (Diploccoccus) Catarrhalis</td>
<td>57.14</td>
</tr>
<tr>
<td>Pneumococcus</td>
<td>44.64</td>
</tr>
<tr>
<td>Pneumobacillus (Friedländer)</td>
<td>37.50</td>
</tr>
<tr>
<td>Bacillus influenza</td>
<td>1.80</td>
</tr>
<tr>
<td>Vincent's fusiform bacillus</td>
<td>7.14</td>
</tr>
</tbody>
</table>

In addition, other organisms were present, viz.,
- Bacillus tetragonus (5.35%)
- Micrococcus (Diplococcus) Gravis.
- Streptococcus brevis (16%) and longus.
- Diphtherial bacillus.
- Vincent's fusiform spirochaete.
- Coliform bacillus.
- Staphylococceus.
- Streptococcus Anglomeratus.
We see, from the above analysis of the organisms detected in the sputum examined that the following occur in much greater frequency than the pest, viz.,

1. *Micrococcus Catarhalis*.
2. *Pneumococcus*.
3. *Pneumobacillus (Friedländer)*.

These three organisms might be very naturally looked for in such pathological conditions as are exemplified by the sixty cases we have reviewed, although we must bear in mind that the *Micrococcus Catarhalis* and the *Pneumobacillus* can be detected even in healthy conditions of the nose, pharynx, and upper respiratory passages.

The *Pneumococcus*, also, can be found in milder lesions than the one in which it is the chief causal agent; thus, it is met with in the scanty and tenacious discharges associated with an acute tracheitis or pharyngitis.

The *Pneumobacillus (Friedländer)* associated with the *Pneumococcus*, is also a causal factor in bronchitis, or in
Catarrh of the upper respiratory passages.

No particular organism was found associated with a particular symptom in any of the cases discussed, for although we find that, in the case of Pte. F. (No. 44), the organism of Vincent (the fusiform bacillus) was present, yet, in Case (No. 42), showing similar symptoms, the organism was not found, although this fact does not preclude the likelihood of its presence. The peculiar fact about these two cases, just instanced, was the "creamy layer" which separated off from the lighter portion of the sputum, and was found at the bottom of the sputum mucos.

This characteristic seemed to point to a necrosis of some portion of the upper respiratory passages.

We are told (22) that Vincent recognised two forms of "amejina"—(a) the diphtheroid type, characterised by the formation of a firm, yellowish-white "false membrane," very like that of diphtheria, associated with only superficial
ulceration; and (b) an ulcerative type, where the membrane is soft, greyish, and foul-smelling, attended with ulceration and surrounding oedema. In the former type fusiform bacilli are present alone; in the latter, which is distinctly the commoner, there are also Spirochaetes.

It is reasonable to conclude that the "creamy layer" in the sputum was, in all probability, a portion of the yellowish-white "false membrane," for, as was pointed out in the section on Bacteriology and Microbial Anatomy in these Notes, the membrane, in the post-mortem examination, did not wash off in a stream of water, but was pulled off with difficulty, and on examination was found to contain large numbers of the fusiform bacilli. In one case (No. 43), fusiform Spirochaetes were found, but in no instance were Spirochaetes and fusiform bacilli found together.

The present-day view in regard to these bacilli is that they are associated.
with various spreading necrotic conditions. It is interesting to read (23) that fusiform bacilli are sometimes present in the secretions of the mouth in normal conditions, in view of the fact that in others among the cases reviewed, these bacilli were found, although the symptoms presented by the patients were not of a severe nature.

Post-Mortem Findings - Chlorine and Mustard Gases.

A table of post-mortem findings in chlorine gas poisoning cases, which came under British and French observation respectively, is shown on the two following pages, along with the results in some of the mustard gas cases.
<table>
<thead>
<tr>
<th>CHLORINE GAS</th>
<th>MUSTARD GAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BRITISH</strong></td>
<td><strong>MY OWN CASES</strong></td>
</tr>
<tr>
<td><em>Skin.</em></td>
<td>Fissures usually superficial.</td>
</tr>
<tr>
<td><em>Skin.</em></td>
<td>Severe affected, hyperasemic.</td>
</tr>
<tr>
<td><em>Larynx.</em></td>
<td>Mucous membrane inflamed, swollen, sloughing, with mucopurulent fluid covering it.</td>
</tr>
<tr>
<td><em>Pharynx.</em></td>
<td>Reddened, congested.</td>
</tr>
<tr>
<td><em>Trachea.</em></td>
<td>Sometimes stifflers.</td>
</tr>
<tr>
<td><em>Large bronchi.</em></td>
<td></td>
</tr>
<tr>
<td>Mucous membrane</td>
<td></td>
</tr>
<tr>
<td>Turgid, congested, presents hemorrhagic spots, more vascular than normal, and slightly oedematous.</td>
<td></td>
</tr>
<tr>
<td>Little affected. Small bronchi intensely congested and oedematous. Trachea very congested, especially at its bifurcation, which is again accentuated in the bronchi, filled with purulent secretion. Sometimes usually seen in lesser bronchi.</td>
<td></td>
</tr>
<tr>
<td>Upper pharynx congested. Tonsil, mucous membrane purple, plum-coloured.</td>
<td></td>
</tr>
<tr>
<td>Intensely congested.</td>
<td></td>
</tr>
</tbody>
</table>
LUNGS. Intensely congested. Pulmonary parac- 
chyma mottled. Increased patches of diffuse broncho- 
emphysema and emphysema. Diffuse 
Collapse. Capillary edema, most marked 
Congestion very marked posteriorly (anteriorly 
parts not affected). Very small patches of 
emphysema. Diffuse broncho-pneumonia 
Areas of emphysema 
maroon-red or seckin with pus in branchicles. 

LIVER. Appearance of fatty degeneration, often presents co 

Sometimes enlarged and congested. 
Submucous hemorrhage often severe. 
Chambers sometimes dilated, sometimes 
ressembling a normal; principally 
K. Apical and K. Ventriculus. 

Kidneys. Congestion sufficiently marked. 
Congested. 

Submucous hemorrhage often severe. 
Chambers sometimes dilated. 

Heart. Congested, soft & enlarged. 
Acute congested. 

Brain. Frequently small petechial hemorrhage 
in the white matter of the brain. Sometimes 
Large cerebral hemorrhage. 
Cerebral hemispheres covered with a petechial blood-thick 
and semi-transparent. Ventricles dilated & filled with hemorrhagic fluid. 

Heart. 

No V. D. H.
GASES USED IN WARFARE.

Lachrymatory gases.

(a) Benzyl bromide. \( \text{C}_6\text{H}_5 \cdot \text{CH}_2\text{Br} \).
Made by the action of bromine on boiling toluene. Liquid, boiling at 210°C.

(b) Xylyl bromide. \( \text{CH}_3\cdot\text{C}_6\text{H}_4\cdot\text{CH}_2\text{Br} \) (tolyl bromide).
A mixture of the three isomeric bromides, made by brominating the mixture of Xylenes at the boiling point. The ortho-compound boils at 216°C, the meta-compound at 212°C, and the para-compound at 218°C.

(c) Bromo-acetone. \( \text{CH}_3\cdot\text{C}_2\text{O} \cdot \text{CH}_2\text{Br} \).
Made from bromine and acetone, a liquid of a powerful odour. Density 1.99.
Nasal irritant, and vesicant.

Di-phenyl-chloro-carbarnine \( \text{(C}_6\text{H}_5)_2 \text{As} \cdot \text{Cl} \).
A yellow oil of faint garlic odour. Boils at 333°C. Density 1.42 at 15°C.
It has pungency rather than smell, and is liberated in extremely small solid particles.

Lung irritants.

Phosgene, Chlorine, and Chloropicrin.

(a) Phosgene (Carbonyl chloride or...
Oxychloride, $\text{COCl}_2$.
Made by passing carbon monoxide and chlorine over powdered and cooled bone, charcoal, or by simply bringing together dry carbon monoxide and dry chlorine in sunlight. The reason for the dryness is because the gas decomposes in presence of moisture to $\text{CO}_2$ and HCl.
A colorless gas at ordinary temperature, condensed by cooling to a liquid boiling at 8°C. It has an unpleasant, suffocating smell.

(b) Chlorine, $\text{Cl}_2$.
Manufactured from hydrochloric acid by the action of manganese dioxide, or from sodium chloride by electrolysis.
A greenish-yellow gas, liquefying at $-34^\circ\text{C}$ under atmospheric pressure, or at ordinary temperature under eight atmospheres of pressure. Forms yellow crystals at $-102^\circ\text{C}$. The liquid form is condensed in steel cylinders, one volume of the liquid yielding three hundred volumes of the gas.
About two and a half times heavier than air when in gaseous condition. The liquid has
a transparent dark greenish-yellow colour. It is a powerful suffocative gas, and
lung irritant.

(c) Chloropicrin (Nitrochloroform) $\text{CCl}_3\cdot\text{NO}_2$,
made from bleaching powder and picric acid. A colourless liquid, boiling
at 112°C. and of density 1.692 at 0°C. The gas has a very penetrating odour, and
a powerful effect on the eyes. It explodes when heated rapidly.

Blistering Gases (Viscants).

(1) Mustard Gas.

(2) Di-phenyl-chloro-arsine (already described).

(1) Mustard Gas (symmetrical dichloro-
dimethyl sulphide, $\text{C}_2\text{H}_4\cdot\text{S}\cdot\text{C}_2\text{H}_4\cdot\text{Cl}_2$).

An oil of faintly sweetish odour. It
boils at 217°C. named Lyséré by the
French. It is liberated in minute drops,
and evaporates slowly, the ground on any
articles contaminated by the gas is therefore
a source of danger for several days.

Made by the interaction of Ethylene and
Sulphur Chloride. With this gas there
is probably combined a little mustard oil (Allyl isothiocyanate), C₃H₅NCS.

References:

2. Les intoxiqués par les gaz asphyxiants au poste de secours, par C. Lian, (ibid).
8. Etude clinique, anatomopathologique et histochimique des cas d' intoxication par les gaz irritants employés par les Allemands à Langemarck, par R. DuJarnie de la Rivière et T. Leclercq, and
(14) The first symptoms of intoxication by Mustard gas, by A. Giraud (Jour. de Med. de Chir., Prat. (Nov. 25, 1917).
(16) Note on blood changes in Gas poisoning, by T. Miller and T. Rainy (Lancet, Jan. 6, 1917).
(19) Medical Diseases of the War, by A. F. Hurst (London 1917).
(21) Text-Book of Medicine, by G. Dieulafoy (London, 1912).
Brief Notes on the Cases.

The following are Notes on Sixty Cases of Gas Poisoning. Of these, nine proved fatal. Fifty-seven cases were under my personal care, and six of these died, viz., Cases 10, 30, 34, 37, 45 and 47.

Notes on the remaining three fatal cases, viz., Cases 9, 14, and 49, were kindly supplied by my colleagues.
Case 1. (?o Mustard gas.
Pt H. gassed 21.7.1917. admitted 27.7.1917.

Symptoms.
After being gassed, he complained of smarting in the throat, and had a "stifling sensation. He vomited immediately thereafter, had headache, and "felt sore" all over the chest; and a "blocked-up" sensation there. He developed broncho-pneumonia and pleurisy with effusion. Aspirated twice. Sputum contained pus, necrosei, was blood-stained and mucopurulent. The blood-stained serum was laden with polymorphonuclear leucocytes. The fluid aspirated on the second occasion was chocolate-coloured, contained gas, and examination of a "smear" showed a large number of polymorphonuclear cells. No organisms were found in the fluid, and a culture of it gave negative results.

This patient had no conjunctivitis, and no burns. I think this case illustrative of a mechanical irritation of the lung and pleura by poison gas.

Case 2. Mustard gas.
Pt H. age 22. gassed 29.10.1917. admitted 31.10.1917.

Symptoms.
On admission, he complained of a dry and "parched"
Throat. There was oedema, sneezing, and patient had a "dull" headache. Slight mucous expectoration. The case was one of severe conjunctivitis and laryngitis, with coryza.

**Bilb.**

A slight amount of mucus. Polymorphonuclear pus.

**Organisms.**

Mononuclear and endothelial.

(many large).

Organisms:

Micrococci (catarrhalis), and pneumococci.


**Symptoms.**

On admission he had severe erythema (face and trunk), slightly (both arms); also severe purulent conjunctivitis with oedema of the upper lids, and cough. A mild bronchitis ensued.

**Sputum.**

Watery, and mucopurulent.

**Cells.**

pus (mainly).

Organisms:

Pneumococci (large number), Micrococci (diphlococci)

Catarrhalis, (Gram negative), and a few diphtheroids.


Symptoms.
After exposure to the gas, he had pain in the eyes, sore throat and headache. A few rhonchi were present over the chest. The case was a moderately severe conjunctivitis and pharyngitis.

Sputum.
Trifthy, mucous.

Organisms.
A few pneumococci, micrococcii (Catarrahalis), and Vincent's fusiform bacilli.

Case 5. (?) Lachrymatory gas.
Pt. H. age 24. gained 24.10.1917. admitted 31.10.1917. He had lachrymation, pain in the chest, cough, and nasal catarrh. There was no vomiting, and no prominent symptom developed.

Sputum.
Slight in amount, watery, and mucopurulent.

Organisms.
Pneumococci (many), diplococci (Catarrahalis), and a few diphtheroids.

Symptoms.
Considerable lacrimation, severe headache, and a sickly feel. This patient had a severe dry cough, and a considerable degree of laryngitis.

Organisms.
M. purulent. Pus, squamous epithelial and alveolar.

Organisms.
Pneumococci (many), micrococci (catarrhalis), and a few diphtheroids.

Case 7. Mustard gas.


Symptoms.
Before admission he vomited, and had severe pain in the throat, chest, and epigastrium. A moderately severe laryngitis developed.

Organisms.
Slightly muco-purulent. Pus and alveolar (many).

Organisms.
Pneumobacilli and micrococci (catarrhalis) — many, a few pneumococci.

Case 8. (?) Mustard gas.
Symptoms.
No prominent symptom. He had slight sore
throat, and slight cough.

Spitum.
Slight amount, watery,
and mucus-purulent.

Organisms.
Microcoeci (catarrhalis), pneumobacilli and
mencoceci (a few).


Mr. L. Passed 2.11.1917. Admitted 5.11.1917.
The following Notes were taken by a colleague of
mine, who was in charge of the case.

Symptoms.
The first symptoms were pain in the eyes and cough,
with sore throat. On admission his general
condition was serious, there being marked
cyanaosis and dyspnœa. Breathing was rapid and
noisy, and 44 per minute. Paroxysmal Coughing,
with quiet intervals. Rapid pulse - 112 - of low
Tension. Percussion note slightly impaired at
both bases. His condition became rapidly worse.
Breath sounds were well heard in the upper lobes,
and the accompaniments were numerous coarse,
Rales and rhonchi. At the bases the breath sounds were deficient, and there were numerous moist rales. The heart sounds were soft and distant. There was dilatation. Oxygen and cardiac stimulants were administered. As cyanosis did not diminish, 20 oz. of blood were withdrawn, and the same amount of saline injected intravenously. The patient rallied slightly, but subsequently cyanosis and dyspnoea again became marked, death taking place after a few hours.

Case 10. Mustard gas.

Symptoms.
The patient was seriously ill on admission. He had superficial burns (back and thighs), considerable nasal discharge, and the mucous membrane of the mouth was abraded. His eyes were severely inflamed. Respiration 36, pulse 122, temp. 101.8. There was abundant frothy and mucopurulent expectoration. Breath sounds much weakened, especially at the bases, and numerous coarse rales were present; anteriorly and posteriorly there were areas of bronchial breathing, and numerous moist rales were heard at each base.
The patient became cyanosed, there was much dyspnoea, death taking place on the second day after admission. (Oxygen was given [in this, as in all the other fatal cases] as a resource which I thought might ameliorate the patient’s serious condition, but, unfortunately, to no avail).

Post-mortem findings.

Larynx + trachea etc.
The larynx, trachea, and large bronchi were purple and raw; here and there the trachea was covered by a whitish membrane.

Lungs.
There was early dry pleurisy, and many subpleural petechiae. The bronchioles were much dilated, many of them contained thick yellow pus, and there was much diffuse broncho-pneumonia.

Heart.
The right side was dilated.

Liver, stomach, etc.
There was no abnormal condition observed in the liver and stomach: the spleen was congested, weighing 14 ½ oz.; the kidneys were slightly congested.

Case II. Mustard gas.
Pt. 7. age 42. gassed 29.10.1917. admitted 31.10.1917.

Symptoms.
Severe conjunctivitis with much lacrimation, laryngitis and trachitis, oedema (eyelids), and slight pleuritic pain at the costal margins.

Sputum.
Water greenish. Pus (many), alveolar (some).

Organisms.
Pneumococci and pneumo bacilli (many), micrococci (cataranthals).

Case 12. Mustard gas.

Symptoms.
The effects of the gas were felt six hours after shelling. This patient had cough, severe conjunctivitis and slight laryngitis. Oedema (eyelids). Slight expectoration.

Sputum.
Mucus purulent. Pus, and (mostly) polymorphonuclear.

Organisms.
Pneumococci (many), a few staphylococci, coli form bacilli, and micrococci (cataranthals).

Symptoms.

Pain (eye, throat and chest). There was erythema of the face. The case was one of conjunctivitis, slight pharyngitis, and moderately severe laryngitis.

History.

Septic, greenish, and mucopurulent. Eosinophils (many), polymorphonuclears (many).

Organisms.

Pneumococci in short chains), micrococi, and diphtheroids (many).


(Note by a colleague in charge of this case).

Symptoms.

He had acute conjunctivitis, laryngitis, tracheitis, and burns (face and hands). Death took place from bronchitis and broncho-pneumonia.

Post-mortem findings.

Larynx and trachea.

The mucous membrane was swollen and inclined to desquamate, and there was much pus in the trachea.

Tissues.

Vitellinums, sub-pleural petechiae, extensive membranous bronchitis, and broncho-pneumonia.
Heart.
The heart was soft and dilated. No V.D.H.
Liver.
The liver, spleen and kidneys were congested.

Of this case I might observe that the treatment was
good.

Case 15. Mustard gas.
Pt. K. age 34. gassed 2.11.1917. admitted 5.11.1917.

Symptoms.
This man had severe conjunctivitis, laryngitis and pharyngitis,
and marked erythema over the body generally. He
developed an acute bronchitis. The 1st sound in cardiac
area was soft, tending to a systolic murmur. He was given
Oxygen for an attack of dyspnoea. The head was dilated.

Cells.
Frothy, and mucopurulent.

Organisms.
Micrococci (bacilliform), many; pneumococci, streptococci (hemolytic).

Pt. O. age 34. gassed 1.11.1917. admitted 12.11.1917.

Symptoms.
He complained of headache, pain in the chest and epigastrium.
He had slight conjunctivitis and pharyngitis.
Organisms.
(Pneumococci & Micrococci) - many; Pneumococci (a few); some Micrococci (Tetragonos).

Case 17. Mustard gas.

Symptoms.
Considerable oedema (papilloedema), slight conjunctivitis and laryngitis. A mild bronchitis followed.

Sputum.
Organisms. Cells.
Slightly purulent. Micrococci (Pus).

Case 18. Mustard gas.
Pte. C. age 40. gassed 15.11.1917. admitted 17.11.1917.
This patient had slight conjunctivitis before admission.
He complained of pains in his chest and feet. A slight degree of Emphysema was present.
The sputum was scanty, of gelatinous consistency, and contained an almost pure culture of pneumococci.

Case 19. Mustard gas.

Symptoms.
He complained of pains in the chest, limbs, and
epigastrium, and had backache, and coryza. A slight degree of laryngitis and bronchitis developed. Cells. Slight, and mucopurulent.

Organisms.

Pneumococci, micrococci (catarrhalis), and diplococci (vaginalis). (Gram positive)

Case 20. Mustard gas.

Pt C. age 25. gassed (?). admitted 20.11.1917.

Symptoms.

The gas had a “musty” taste. There was slight conjunctivitis, with severe laryngitis and pharyngitis. (Ephelides developed on second day after admission)

Organisms.

Streptococci (hemolytic), micrococci (catarrhalis), Vincent’s “bacilli” (vaginalis)


Pt R. age 25. gassed 17.11.1917. admitted 20.11.1917.

Symptoms.

The gas “smelt of stale mustard.” The first effects were felt about 12 hours after gassing, and pain in the chest was experienced 36 hours after he was “gassed.” The patient had severe laryngitis, and tracheitis.
Case 22. Mustard gas, and (?) Diphenyl-chlor-arsine.

L.D., gassed 17.11.1917, admitted 20.11.1917.
This man had lacrimation, throbbing in the head, and a sensation as if the contents of his chest were turning over. He felt dizzy and vomited on the following morning. Cough was present and slight expectoration, but no marked chest symptoms or hoarseness.

Spectrum.

Pus, frothy, and slightly muco-purulent. Pus (a few).

Organisms.

Pneumococci (many), Diplococci (cataarrhalis) and (rarely), Streptococci (brevis) longus, a few fusiform bacilli.

Case 23. Mustard gas.


Symptoms.

He complained of pain in his chest and throat, and had severe frontal headache with abdominal pain. Very slight laryngitis on admission. A few moist rales were present at both bases.
Sputum.
Slightly mucopusulent.

Organisms.
Diplococci (Catastral) - many, Streplococci (fever) - a few.

**Case 24.** Mustard gas.
R. R. C. age 34. gassed 20.11.1917. admitted 27.11.1917.

Symptoms.
Five hours after being gassed he had lachrymation, headache, dry throat, vomiting, and a burning sensation in the skin. There was erythema of the forehead, neck, lower portion of the right thigh, and upper portion of the right leg. Almorrhea bilat. phr. laryngitis. Pharyngitis. Sputum.
Frothy and mucopusulent. Red and squamous epithelial, acting as Phagocytes.

Organisms.
There were numerous organisms within the Phagocytes, viz., pneumococci and parasinuscilli, micrococci - (Catastral), and diphtheroids.

**Case 25.** Mustard gas.

Symptoms.
Severe conjunctivitis and headache, cough, vomiting,
pain in throat and chest. There was severe erythema of the eyelids and forehead, and a considerable degree of laryngitis. There was slight pyrexia for several days.

**Symptoms.**

- Slight amount, mucous-purulent. Pus and epithelial (mainly).
- Organisms.
- Micrococci (catarrhalis), and streptococci (brevio).

**Case 26.** (?), Diphosph-chloro-arsine, Mustard gas.

- Age 29, gassed 24.11.1917, admitted 26.11.1917.

**Symptoms.**

- Eyes “watered” but were not painful, outside of the nose felt hot, also the roof of the mouth. There was severe cough & headache. He “ached all over,” especially in the chest. 1st sound in Mitral area was accentuated.

**Organisms.**

- Slight, gram-positive.
- Organisms.
- Streptococci, and diplococci (catarrhalis) - a few.

**Case 27.** Mustard gas.

- Pte N. age 21, gassed 22.11.1917, admitted 25.11.1917.

**Symptoms.**

- Headache, vomiting, lacrymation, slight sore throat, & lumbar pain. Discoloration 3 days after admission.
Case 28.  Mustard Gas.

Mr. H. age 26.  gassed 22.11.1917. admitted 25.11.1917.

Symptoms.

Throat, dry cough, chest was "tight and sore," severe pain in the eyes.  Lachrymation, the main condition was a severe conjunctivitis.

Organisms.
Micrococci, (diphtheriae) / Catarhalis (Gram negative).

Case 29.  Mustard Gas.

Mr. B. age 30.  gassed 22.11.1917. admitted 26.11.1917.

The gas tasted like "horseradish sauce." There was pain in the throat and chest twenty-four hours after "skirling," headache and vomiting. This man developed a severe laryngitis, and a mild bronchitis.

Organisms.
Micrococci, tetragenus, diphtherieoccus, pneumococci and streptococcus. longus.
Case 30. Mustard gas.


Symptoms.

On admission this case was seriously ill. There was much pain in the eyes and chest, lacrimation and sore throat. Marked erythema (face). There were numerous phlegm on the chest wall, and numerous moist rales at the bases of the lungs, where the breath sounds were faint. There was much oedema of the lung tissue.

The case was one of severe laryngitis, tracheitis, and conjunctivitis, with a generalized bronchitis, terminating in a fatal broncho-pneumonia.

Postm. Cell.

Pus, acute, mucous, subpleural. Pus, endothelial.

Organisms.

Pneumococci (many), micrococcus (catarrhalis), and a few Vincent's fusiform bacilli.

Case 31. Mustard gas.


Symptoms.

Lacrimation, cough with expectoration and pain in the chest. On admission there was slight pyrexia, and considerable erythema (the face and neck blistered).
The voice was husky and toneless. There was severe conjunctivitis and laryngitis.

Organisms.

Streptococci, pneumococci, and micrococci (Catarhalis).

Case 32.

Lachrymatory or Mustard Gas.


Symptoms.

Severe pain (eyes), cough, loss of voice, and the "feels like a heavy cold." The main condition were a severe laryngitis and conjunctivitis.

Sputum.

Wet, mucous, and purulent. Pus and alveolar.

Organisms.

Streptococci (Gram positive), pneumococci, (Catarhal), Gram neg. (large numbers); pneumococci, streptococci (agglomerates) and a few.

Case 33.

Lethal gas (?) Phosgene


On admission he had slight lachrymation, cough, with slight hoarseness, epigastric pain, and shortness of breath.
Sputum. Cells.
Slight amount, muco-purulent. Pus (mainly); a few neutrophils, occasional, squamous epithelium.

Organisms.
Pneumococci and micrococci (catarrhalis); and pneumococci, with streptococci (brevi) - a few.

Case 34. Mustard gas and Phosgene gas.

Symptoms.
On admission he had severe pain (eyes and throat), cough, severe pain in chest, very rapid pulse, and pyrexia. There were numerous phrenicis over the chest wall (aud. & post). Abundant moist rales at both bases, where the breath sounds were faint. The patient became gradually weaker, and his respiration, on sixth day, after admission, was 52, pulse rate 158.

Hyperpyrexia on sixth day. Death occurred on the eighth day after admission.

Sputum. Cells.
Watery, greenish-yellow, offensive. Purplur, large numbers.

Organisms.
Pneumococci (numerous), and a few streptococci (brevi), and streptococci (brevi).
Case 35. Mustard gas.

Symptoms.
On admission he had lacrimation, cough, cough with expectoration, and pyrexia. There was extensive blistering, which involved the thighs, buttocks, and one side of the face. He felt weak all over.

Postum.

Inco-purulent.

Organs.

Micrococci, pneumococci, and diplococci (coccus).

Case 36. Mustard gas.

Symptoms.
Lacrimation, cough with expectoration, sore throat and pain in the chest. Sore conjunctivitis laryngitis noted.

Postum.

Inco-purulent.

Organs.

Micrococcus (cattarrhalis) (large numbers), pneumococci (many), a few micrococci (tetragonus).
Case 37. Mustard gas.
Pt. B. gassed — admitted 25.5.1918.

Symptoms.
On admission the patient had severe conjunctivitis (mucopurulent), laryngitis, pharyngitis, and burns in the groin and thighs. He was very restless, and later, became slightly delirious.
There were numerous phthochi, and many fine, whitish rales were present in the lower lobes (posteriorly).
The patient died on the fourth day after admission.

Post-mortem findings.
Larynx and trachea.
The larynx and trachea were injected and ulcerated, and there was much thick yellow "false membrane" present.

Lungs.
In the lungs there were many sub-pleural petechiae, also a plastic pleurisy on both sides.
The lungs were voluminous, and several scattered areas of collapse were present. Consolidation was noticed to be spreading from the roots, where there were enlarged glands.

Heart.
The heart was dilated and flabby. No V.D.H.
Case 38. Mustard gas.


Symptoms.
Lachrymation, sore throat, dry cough, and pain in chest. The gas "tasted of mustard and horse-radish," and made him vomit. The main condition was a severe laryngitis, and a moderately severe conjunctivitis.

Sputum.
Watery and mucous-purulent. Rhus, epithelial, glandular.

Organisms.
Pneumococci (many), streptococci (Bacillus), and diphtheroids (a few).


Symptoms.
On admission, he had pain in the eyes, throat, and chest. A mild conjunctivitis and laryngitis developed.

Sputum.
Largely mucous, slightly purulent. Rhus.

Organisms.
Pneumococci (many), a few streptococci.
Case 40. Mustard gas.


Symptoms.

Pain in eyes, throat & chest, with cough. The heart sounds were weak. There was an acute conjunctivitis, slight emphysema, and a few stippled phonochi and moist rales at both bases.

Sputum.

Cf. copious, watery, greenish. Pus, alveolar, and squamous epithel. (Phagocytes) of Lungs.

Organisms.

Pneumococci and micrococci (within the phagocytes) & a few streptococci (brevis).

Case 41. Mustard gas.


Symptoms.

Acute conjunctivitis, with oedema of the eyelids. There was oedema of the chest, and of the face. A mild bronchitis developed.

Sputum.

 Bloody, and mucoid-purulent. Pus (mainly) & many polymorphonuclear leucocytes.

Organisms.

Many pneumococci & pneumobacilli. Some streptococci, and a few fusiform bacilli.
Case 42. Mustard gas.

Adj. S.

Symptoms.

On admission, his face was suffused and slightly blistered. He had pain principally in the throat and the upper portion of the chest. Cough was continuous and painful. The 1st sound (Mitral area) was weak. This man coughed up a good deal of frothy mucus, from which a thin, creamy layer separated off. There was later, a good deal of watery expectoration, and following this, the sputum became somewhat viscid. Sputum.

Frothy, with separation of "creamy" layers.

Organisms.

Streptococci, diplococci (laborhali), and pneumococci within the phagocytes.

Case 43. Mustard gas.

Chef. W.

He complained of severe pain (eyes and throat).

The condition was a purulent conjunctivitis, severe laryngitis, and a mild bronchitis.
Mustard gas.

**Case 44.** Mustard gas.

Pte. F. age 26. gassed 1-12-1917. admitted 3-12-1917. He had severe cough and sore throat, the eyes were very painful, he had a "burning feeling" in the face, which was slightly blistered. The case was one of acute purulent conjunctivitis, and moderately severe laryngitis.

**Sputum.**

Frothy, viscid, with separation. Cells.

Creamy deposit. Pus.

**Organisms.**

Pneumococci, micrococci (catarrhalis) and streptococci (brevis) — large numbers. There were a few of Vincent's fusiform bacilli present.

**Case 45.** Mustard gas.

Pte. H. age 23. gassed 1-12-1917. admitted 3-12-1917. He was seriously ill on admission, and much
Burnt on the face and hands, and slightly blistered on the chest. He had severe pain in the eyes and throat, and distressing cough, with much viscid muco-purulent sputum. There was acute conjunctivitis, and severe laryngitis and tracheitis, acute bronchitis, and broncho-pneumonic consolidation. The patient died on the eleventh day after admission.

Sputum:
Viscid and muco-purulent.

Organisms:
Bacillus influenzae (numerous), + some pneumococci.

Case 46. Mustard gas.

Symptoms:
Cough, slight aphonia, face suffused and slightly blistered. He had conjunctivitis and severe laryngitis, there were a few moist rales at both bases. The gas "smelt like pepper."

Sputum:
Watery and muco-purulent.

Organisms:
Pneumococci and pneumostacilli.
Case 47. Mustard gas, ? Pheugue gas.


Symptoms:
Diffuse erythema of face, trunk, upper portions of thighs, genitals. He was seriously ill on admission, and had severe laryngitis, purulent conjunctivitis, and acute bronchitis. There were numerous moist rales at both bases, and the breath sounds were very faint over both lower lobes posteriorly.

The patient became dyspnoeic and cyanosed shortly after admission, and died on the third day after admission to hospital.

No post-mortem examination was made.

Post-mortem.

Lungs: (almost entirely)

Purulent, yellowish-white and mucus-purulent.

Organisms: Pneumococci (numerous), pneumococci, and micrococci (catarrhalis).

Case 48. Mustard gas.


Symptoms:
Pain (eyes and chest), and dry cough. He developed a severe conjunctivitis and laryngitis.
Mucous purulent. Purvalveolar (many).
Aqueous epithelial (as Phagoctye).

Case 49. Chlorine and Phosgene gases.

(The following notes were taken by a colleague of mine who was in charge of the case.)

An answer (Division) withdrawn at advanced Dressing Station, where also Oxygen was administered.

On admission, the apex of the heart could not be accurately located. The lungs were emphysemaous; there was pleural friction at the right base, and much secretion of the left base, with numerous crackling and bubbling rales on both sides of the chest wall posteriorly. There was much viscid expectoration. On the eighth day after admission he became slightly cyanosed, and Oxygen was given (with short intervals of rest) frequently. Division gave a little relief, as the patient obtained a fair amount of sleep on the following day. He again became cyanosed, and died on the thirteenth day following admission.

Case 50. Mustard gas.

Symptoms: Pain (eyes, chest, and epigastrium), and slight cough.
A mild bronchitis ensued.

Sputum:

Sputum, mucous-purulent. | Pharyngitis, tracheitis.
Organisms:

Pneumococci, pneumococci, and streptococci (febris).

Case 51. Mustard gas.

Symptoms:

Rash, throat and chest, and cough with expectoration. Blister on the right buttock and left thigh. On admission he had conjunctivitis and moderately severe laryngitis.

Sputum:

Frothy, viscid, and mucous-purulent.

Organisms:

Pneumococci and haemmorhagic (catarrhalis).

Case 52. Mustard gas.

Symptoms:

Slight cough and expectoration. There were no main symptoms. The patient's temperature was subnormal during the greater part of his stay in hospital. Transferred to Convalescent Camp. 1.1.1918.
Nontum.

Mucus.

Organisms.

Pneumococci and micrococci (cattarrhales) — many; diplococci (pus); and a few diphtheroids.

Case 53. Mustard gas


Symptoms.

On admission his voice was very husky. The condition was one of acute conjunctivitis, and laryngitis; there were some (scattered) rhonchi over the chest-wall.

Nontum.

Mucous membranes.

Organisms.

Pneumococci and pneumococci (pus); and many micrococci (cattarrhales).

Case 54. (?) Chloropicrin gas.


He complained of pain in the throat and chest, and was sick and giddy two hours after being gassed. There was lachrymation. On admission he had frontal headache, pain, and "tightness" in the chest.
There were no main symptoms beyond a few moist rales posteriorly.

Sputum:

Mucopurulent. Squamous epithelial (Phagocytes).

Organisms:

Pneumococci, micrococci (cataarrhalis), streptococci (longus and brevis), and a few diphtheroids.

Case 55. Mustard and (?) Lachrymatory gases.


Symptoms:

Lachrymation, sore throat (aphonia developed subsequently), pains (chest, loins, and shoulder joints). Slight vomiting previous to admission. The breath sounds were faint posteriorly.

Sputum:

Cells. Dark, mucous. Pus (a few).

Organisms:

Spherooccus cerasus (a few), pneumococci and micrococci (cataarrhalis) - many.

Case 56. Mustard gas.


Symptoms:

Lachrymation, vomiting, and pain in the chest.
Case 56 (cont'd).
On admission there were no marked symptoms beyond slight precordial pain, and a small area of bronchial breathing near the sixth rib (in nipple line) on the right side of chest. No pyrexia or burns.

Symptoms.
Mucous-purulent.

Organisms.
Pneumococci and micrococci (catarrhalis) = many.

Case 57. Mustard gas.

Symptoms.
Pain in the eyes, throat and chest. On admission he had severe conjunctivitis (slightly purulent), and laryngitis, with slight oedema (groins).

Organisms.
Largely mucous.

Pneumococci (a few), micrococci (cataarrhalis), many.

Case 58. Mustard and (?) Lethal gas.

Symptoms.
Pain in chest, vomiting, and giddiness.
Further symptoms were present beyond a few coarse rales in the right side of the chest, which felt heavy.

Sputum: cells.
Slightly mucopurulent.
Organisms: *Pneumococcus* (a few), *M. catarrhali* (many).

Case 59. Mustard and (?) Phosgene gases.
Pt. W. gassed 20.2.1918. admitted 1.3.1918.

Symptoms: Eye and throat were “parched” and painful; there was headache, and the patient vomited greenish fluid before admission. The heart sounds were feeble, and a few rhonchi were present, posteriorly. The gas smell “like the dirty fumes from a motor car exhaust.” There were conjunctivitis and severe laryngitis.

Sputum: cells.
Purulent.
Organisms: *M. catarrhali*.
Case 60. (9) Mustard gas and Lachrymatory gas.


(The following notes were taken by a colleague in charge of the case.)

Severe cough (paroxymal), pharyngitis, and very slight Laryngitis. He developed a mild Bronchitis. Laryngitis persisted till 16.1.1918, when he was sent to a Convalescent Camp.

On admission to a Base Hospital he complained of pain in the chest, hips, knee-joints, and shins.

The majority of the cases described in these sixty enumerated were cases of Mustard gas poisoning; in the few instances in which an admixture of gases was suspected, the treatment considered appropriate was given.

The methods of treatment which I found the most beneficial in the majority of cases, were generally adopted, and were as follows: -
Chlorine gas.

(1) Rest; warmth; fresh air.
These were the main essentials of treatment.

(2) Diluent warm drinks frequently administered, fluid diet, stimulating expectorants (as indicated in the section on Treatment [pp. 60-61]) and the administration of oxygen brought about a very great improvement in cases which, at first sight, appeared to be hopeless.

---

Mustard gas.

Similarly. Rest; warmth; fresh air were all essential.

The use of alkaline lotions for the body and eyes, of picric acid as a dressing for burns, together with the "mask" treatment for the laryngeal or tracheal states, and the administration of a mild expectorant mixture (when indicated) generally brought about a rapid convalescence in all the cases excepting those of a grave nature.
ON CERTAIN ASPECTS OF GAS POISONING IN WAR.

BEING OBSERVATIONS ON

- EFFECTS.
- TREATMENT.
- BACTERIOLOGY.

F.R. BREMNER, M.A., ST. AND., M.B.,C.M., L.R.C.P., L.R.C.S., EDIN.