OBSERVATIONS ON 685 CASES OF POISONING BY NOXIOUS GASES USED BY THE ENEMY.

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The following notes are founded on observations on 685 cases of gas poisoning which came under treatment in a casualty clearing station between May 2nd and May 7th, 1915. The patients were brought in by motor ambulance convoys from the field ambulances—a journey of about ten miles. Some arrived only six hours after being “gassed,” while in other cases a much longer period had elapsed before they were brought in. They were detained in the casualty clearing station only until they were deemed fit to evacuate to the base. The slighter cases were sent down at the earliest possible moment, the majority were evacuated within forty-eight hours, while a number of severe cases were kept for several days while their condition remained critical. The total number of cases admitted during this period was 685. They were suffering from all degrees of asphyxia, but no good reason could be given why some cases were much worse than others from the same trench. It was, however, observed that the older men were almost all severe cases.

Extreme pressure of work made it impossible to make notes on each case, but the following general features have been observed with care, and it is hoped may be of interest and assistance to others.

The whole series could be roughly divided into two groups:

- (a) Those who seemed in imminent danger of death from asphyxiation—about 120 in number.
- (b) The remainder who, although suffering from the effect of the gas, did not appear in immediate danger.

Of the first group 33 died, giving a death-rate in the total number of cases observed of just under 5 per cent. It must be added here that many other cases died either on the field or at the field ambulances.

Of the 33 deaths:

- 16 died on the day of admission.
- 13 died on the day following admission.
- 2 died on the second day following admission.
- 1 died on the third day following admission.
- 1 died on the fourth day after admission.

It will be seen that 29 of the 33 deaths took place within thirty-six hours after admission, only 4 dying at a later period.

CONDITION OF CASES ON ADMISSION.

The first intimation that the urgent problem of asphyxia would have to be faced on a large scale was the arrival of the convoy, and it is difficult to convey the mental impression produced when the first batch were unloaded. It was 1.30 a.m. when they reached the casualty clearing station, the gas having been used against them about 7.30 p.m. on the previous evening. One man was dead before he could be removed from the ambulance. Most of the others were in a choking condition, making agonizing efforts to breathe, clutching at their throats, and tearing open their clothes. At one moment they propped themselves up to gasp, at another they fell back exhausted by their struggles. There was marked cyanosis, especially of the lips and ears, and in a few cases a light yellowish frothy discharge was escaping from the mouth and nose. Some, especially the older men, were in a condition of collapse; their faces and hands were of a leaden hue, their heads fallen forward on their chest. The majority of these cases did not rally. In addition to the asphyxiating effects of the gas, most of the men, although young

and robust, were greatly exhausted by continuous fighting against the poison.

All, except those moribund or collapsed, were fully conscious, and fighting desperately for life.

Fourteen men died out of the first batch of seventeen admitted.

Among the hundreds of cases subsequently observed, all degrees of asphyxia were evident, and it is difficult to convey a composite clinical picture of all of these. Certain common features, however, stood out so prominently that our purpose will be served by calling attention to them. Certain of these have been alluded to already.

The typical case was on admission cold, with a sub-normal temperature, conscious but restless, the pulse slow and full (except in the collapsed cases). The face was cyanosed, intensely so in many cases, and the expression was strained and anxious. The posture varied. In some cases the patient sat propped up, with head thrown back, gasping for breath; in others he lay on his side with his head over the edge of the stretcher in an attempt to aid expectoration. The respirations were jerky and hurried, often numbering forty a minute, and were associated with a choking cough, accompanied by a varying amount of frothy expectoration.

With each inspiration the chest was expanded to its fullest, all the auxiliary muscles being brought into play just as in an asthmatical paroxysm.

The percussion note over the chest was somewhat impaired without being actually dull. Auscultation revealed the presence of moist sounds of different qualities all over the chest.

PROGRESS OF THE CASES.

It was noticed that the patients who lived tended to pass through three more or less definite stages while under our observation:

1. The asphyxial stage.
2. The quiescent or intermediate stage.
3. The bronchitic stage.

Nearly all the cases on admission were in the first or asphyxial stage, which has just been described. This condition demanded immediate and energetic treatment, and was that which chiefly occupied us at the casualty clearing station. Grave symptoms appeared with startling suddenness, but if patients could be safely brought through this stage, recovery was the rule.

The first stage gradually passed off after some thirty-six hours, and the patient fell into a sleep from which he woke feeling much better. He continued in this state for perhaps half a day, and during this period every effort was made to evacuate him safely to the base.

After these few hours of comparative quiet, symptoms of bronchitis began to manifest themselves. In the majority of cases, as far as our experience went, these were not severe. In the cases, however, which had been kept alive with difficulty there was a very short quiescent stage, followed by intense bronchitis. Four of the most severe cases died in this bronchitic stage. Their symptoms, as compared with the first stage, were as follows: The frothing secretion gave way to thick greenish mucopurulent expectoration, consciousness was replaced by delirium, temperature rose from subnormal up to 104° F., and the pulse became of small volume, while its rate increased to perhaps 160. Respirations were less choking, but more shallow, and numbered up to 70 per minute before death.

TREATMENT.

As *post-mortem* examination showed that the patients died of acute congestion and oedema of the lungs, the aim of our treatment was:

1. To expel the excessive secretion from the lungs by emetics and stimulating expectorants.
2. To diminish the secretion.
3. To support the failing heart and reoxygenate the blood.

General Treatment.

On arrival the patients were placed in the open air, and, as they were very cold, extra blankets, hot-water bottles, and hot drinks were provided.

A little later on, as the weather was unsettled and to facilitate nursing, the worst cases were placed in a large, lofty room with open windows on opposite sides, giving a

through draught. Here about 120 out of the 685 cases were treated, the maximum number in the ward at one time being 30.

Special Treatment.

1. *Emetics.*—As a routine measure, the first 80 cases admitted were treated with emetics. Later on their use was confined to those cases which were obviously choked with secretion, and had not already been sick. The most successful emetic was salt and water, administered in 10 oz. doses, followed by large draughts of lukewarm water; vomiting was *immediately* induced by tickling the back of the throat with a soft brush, or by the patient using his own finger. In all cases marked relief was experienced, the patients bringing up quantities of yellowish frothy fluid. In fact, so pronounced was the relief, that many tried to make themselves sick again. Vinum ipecacuanhae and apomorphine hydrochloride were also tried, but were discarded, neither being so certain in their action as salt and water. There was no difficulty in getting the men to take the latter remedy, even in the most acute cases.

2. *Artificial Respiration.*—The action of the emetics was furthered in selected cases by the application of Schäfer's method of artificial respiration. The results at times were strikingly successful, notably in the case of one man, almost moribund, who was treated in this way on four successive occasions, and who ultimately recovered.

3. *Stimulating Expectorants.*—Every case was given ammonium carbonate gr. x every three hours, as a stimulant and expectorant. Later this dose was increased to gr. xv and vinum ipecacuanhae m xv added. This mixture, although containing a somewhat large dose of ammonium carbonate, frequently given, gave very good results, producing copious expectoration followed by improvement in colour and general relief. In the 80 cases treated with emetics the expectorant followed.

4. *Posture.*—The action of emetics and expectorants was sometimes aided by altering the position of the patient, from sitting up to lying on the side, with the head low down to aid expectoration.

To Diminish Secretion.

In the hope of being able to check the excessive secretion in the lungs, atropine was administered to several severe cases, in doses of gr. $\frac{1}{16}$. We cannot say we found any beneficial result from this treatment; doubtless its administration was too late, but it might have been of use if given earlier—that is, in the field ambulance.

To Support the Failing Heart.

Venesection.—In view of the cyanosis and marked dyspnoea, venesection was attempted, 10 to 15 oz. being removed on each occasion. This proved very difficult to carry out satisfactorily as the blood clotted rapidly, and the relief given was very transient. It occurred to us that a more gradual and protracted depletion of the right heart would give better results. Accordingly leeches were procured. Sufficient suitable cases did not then remain, however, to enable an opinion to be formed as to their value.

Pituitary Extract.—Whenever the pulse showed signs of weakening—which was rarely seen except in cases approaching a fatal termination—1 c.cm. of pituitary extract was given, with marked benefit, the pulse becoming fuller and slower.

Oxygen.—As most cases presented marked cyanosis and dyspnoea, oxygen was given freely by inhalation; there was no doubt that temporary benefit resulted, the restlessness decreasing and the colour improving. Continuous inhalations appeared to give no more benefit than intermittent ones. In one or two cases oxygen was given by subcutaneous injection in the pectoral region, the amount being sufficient to cause a lump in each side of the chest about the size of a small football. This was absorbed very slowly, and no relief was apparent.

Benzoin Inhalations.—In milder cases, when the alveolar and bronchial secretion was not so marked as the irritation of the larynx and trachea, inhalations of steam impregnated with compound tincture of benzoin, in a closed tent, were tried with some relief.

Opium.—There was a type of case in which the mental strain was a more marked symptom than the pulmonary distress. This type was characterized by extreme rest-

lessness rather than by dyspnoea, and in these cases tincture of opium, m v administered every half-hour until m xv had been given, gave certain relief, the patients quietening down and falling into a peaceful sleep.

Other Remedies.—Other remedies, such as inhalation of chloroform and amyl nitrite, were tried, but without success.

Routine Treatment Evolved from Experience.

The routine treatment evolved from the experience gained was:

1. Abundant supply of air and warmth.
2. An emetic of salt and water if the patient was very cyanosed and had not already vomited, followed by the
3. Administration of ammonium carbonate gr. xv and vinum ipecacuanhae m xv three-hourly.
4. Oxygen inhalation in cases of marked cyanosis and dyspnoea.
5. Opium m v to m xv in restless cases to allay the mental strain.
6. Pituitary extract (1 c.cm.) and brandy when the heart threatened to fail.

PATHOLOGICAL CHANGES FOUND IN CASES DYING FROM THE EFFECTS OF THE GAS.

Post-mortem examinations (10 in all) have been made in cases dying at periods varying from less than a day to five days after inhalation of the gas. Only relative differences were found, even in cases dying at different periods after the gas attacks, so that a general description is sufficient.

The most important changes were found in the lungs, but some changes of note were present in the heart and stomach.

Respiratory System.

In the larynx there was in several of the acute cases a distinct but not marked degree of oedema glottidis. The internal surface of the larynx was congested, even the epiglottis being involved, but not nearly to the same extent as the trachea.

The mucosa of the trachea showed in nearly all the cases intense congestion and oedema, and this could be traced down into the larger bronchi. In almost every case *post mortem* the trachea and bronchi were filled with a thin, light yellow frothy secretion, which was found escaping from the nose and mouth of the cases when they were laid on the *post-mortem* table. This secretion was highly albuminous and solidified like white of egg when heated. The large bronchi only could be traced, the smaller being lost in a condition of intense congestion and oedema, which affected the lungs as a whole. The lungs *in situ* were in most cases voluminous, and bulged forward so as partly to cover up the area of pericardium normally left bare. The most notable characteristic of the lungs, when removed, was their increased weight, which was several times greater than the normal. The pleural surfaces of the lungs could be mapped out into patches of lighter grey and dark greyish-brown, and the pathology of their appearance will be returned to in a moment.

There were subpleural haemorrhages in all but one case. These haemorrhages were small, but in some cases extremely numerous; the lung tissue when incised was found to be of deep maroon-red colour, and fluid secretion flowed in great abundance from the cut surfaces. The structure of the lung could scarcely be made out on the cut surface, the small bronchi being hidden amid the intense congestion. In one case considerable haemorrhage had occurred into one lobe, giving rise to an area about the size of an orange, resembling microscopically a large haemorrhagic infarction. A slice of lung cut from this area sunk in water.

To return now to the light grey patches on the surface of the lungs. These were most numerous along the margins of the lungs and on the diaphragmatic surfaces, but were present up to the very apices. They were found to be areas of actual acute emphysema, and air could readily be made to pass from one side of such an area to the other. In one case bullae of about the size of a small marble were present along the interior margins of the lungs. The emphysematous process did not extend in any area for more than a depth of half an inch into the tissue of the lung from the pleural surface. The margins o

these patches were clearly, but not quite sharply, demarcated from the lung tissue beyond, as the congestion was not at all marked in these emphysematous areas. In several instances the lymphatic channels below the pleural surface of the lungs stood out as prominent lines filled with opaque fluid, there being evidently considerable obstruction to the lymphatic flow.

The Heart.

The heart was in all cases seen to be distended even before the pericardial sac was opened. The dilatation affected all four chambers of the heart, but especially the right auricle and right ventricle. On opening the heart all the cavities were found filled with recent clot, no *ante-mortem* thrombus being found.

Abdomen.

None of the abdominal organs showed more than a condition of venous congestion, except the stomach. The liver in the case of one man who died five days after inhalation of the gas appeared fatty, but this observation has not so far been controlled by microscopic examination.

The Stomach.

The stomach when opened was in all cases found to be in a condition of marked catarrh. The mucosa was covered with a thick yellowish mucus, and submucous haemorrhages were present in nine cases out of ten examined. In one case the amount of submucous haemorrhage present was extreme, and covered almost half of the inner surface of the organ.

The Head.

The head was examined in the majority of the cases, but nothing beyond marked congestion of all the vessels, both of meninges and in the cerebral tissue, could be found.

Histology is pursued here under great difficulties, and in consequence microscopic sections have only been prepared so far from the lungs. The specimens are interesting, however, as they bear out all microscopic observations with regard to the areas of emphysema. The chief microscopic appearances were briefly these: The parts of lung tissue not affected by the emphysema showed marked congestion of the capillaries, and many alveoli, but not by any means all, were seen to be filled with an albuminous amorphous substance taking up the eosin stain. In this substance fibrin could be here and there detected, along with red corpuscles and a few leucocytes. A few alveoli were observed filled with preserved red blood corpuscles.

In the portions of lung affected by emphysema the microscopic changes were very different. Many of the alveoli were broken down, so that perhaps a group of five or six had run into one. The broken free ends of the alveolar walls appeared in the sections more or less bulbar shaped, with a darkly stained cap of amorphous appearance on the top. The alveoli not broken down were obviously much distended, being almost twice the size of the normal lung alveoli under the same magnification. This condition of distension had quite obliterated any tendency to congestion of the alveoli capillaries, the walls of the alveoli being found thin and practically free from blood corpuscles.

These facts account for the light grey colour of the emphysematous patches as compared with the rest of the lungs. The bronchi in the areas of emphysema were empty of contents, in contrast to the congested and oedematous lung tissue in other parts, where the alveoli were found filled with the amorphous eosin-staining material already referred to.

SUMMARY.

From the foregoing account, it seems desirable to emphasize certain points again. None of the cases remained in the casualty clearing station for more than five days after the inhalation of the gas. It is thus the acute stages only which are described in this paper.

On admission the cases were of two chief classes:

1. The acute asphyxial.
2. The subacute.

Of the first class almost one-quarter died. This class was characterized by orthopnoea and marked cyanosis. The subacute cases, on the other hand, showed dyspnoea never amounting to orthopnoea, and were cyanosed to a lesser degree.

It must be admitted that treatment of the acute asphyxial cases was unsatisfactory, which is not to be wondered at when considered along with the changes found in the lungs *post mortem*. The subacute type, however, responded well to treatment, and the cases, although distressed by constant coughing, all admitted the relief gained. The treatment found most satisfactory in such cases was the frequent administration of ammonium carbonate in full doses.

Now that respirators of an efficient type have been issued to the troops it is hoped that many cases requiring to be dealt with will conform to the subacute type, when treatment is of avail.

NOTE BY COLONEL SIR WILMOT HERRINGHAM, Consulting Physician.

I saw a large number of these cases myself and can confirm the report in every particular. Subsequent experience has shown that the milder cases, which are the large majority, recover fairly well. A medical officer of one battalion, who stayed with the battalion in the trenches through a fairly severe "gassing," is now back again in good health after about a month's convalescence.

The problem is how to prevent the severe cases.

I have not the least doubt that proper respirators properly used will almost entirely stop their occurrence. This was proved in the last attack. One battalion with a fairly good pattern of respirator, well used under the intelligent direction of its officers, stayed in its trenches and suffered hardly at all.

Accidental cases will now and then occur, however.

In experiments on animals, atropine given in the earliest stages undoubtedly prevents oedema. I have, however, been surprised to find that no field ambulance reports very favourably upon it. In fact, of the five or six field ambulances which have treated these cases and have told me their experience, no two recommend the same drug or the same method. This difference of opinion shows at least that no other drug appears to be of great value. I hope that if more gas attacks occur we shall be able to try the effect of atropine at an even earlier stage than the field ambulance, and to try it rather more systematically.

When the oedema has once set in there is nothing to be done but to aid the patient to expel the fluid and maintain his strength. The opinion at the casualty clearing stations is almost unanimous in favour of ammonium carbonate.

Only a few cases have remained in the stations, and therefore under my observation, to the stage of bronchitis and bronchopneumonia. These patients, who are dangerously ill, seem to do better with soothing than with stimulant remedies.

The later stages will, however, I hope, be described by medical officers of the base hospitals, who have seen far more of them than I.

It seems certain that the drift gas whose effects are here described is either entirely or almost entirely chlorine. The shells contain other poisonous gases.

MR. HEATH HARRISON, shipowner of Liverpool, has presented a sum of £10,000 to the university of that city for the endowment of the chair of organic chemistry recently established by the council, and filled by the appointment of Professor R. Robinson, of the University of Sydney.

We learn from *Nature* that Mr. C. W. Mally has published an account of the use of sodium arsenite in South Africa as a poison for flies. The bait used is made by dissolving one pound of sodium arsenite and ten pounds of sugar in ten gallons of water. The liquid is applied with a syringe to non-absorbent surfaces, to pieces of canvas, to manure heaps, and rubbish tips. Bunches of twigs, of trees the leaves of which, when plucked, do not crinkle and drop off, are dipped in the solution and hung up where the flies congregate; the flies drink the poison, and die, it is said, literally in heaps. In military camps the method has been applied with success, and, in the absence of suitable trees, pieces of canvas have been sprayed and hung up, and the bait has been sprinkled near manure heaps and other places where flies gather; the bait is, of course, a human poison, but in military camps there is no risk in its use. The method has proved extremely effective for the house-fly out of doors, and its use for fruit-flies has shown that an apparently reckless use of arsenite is not attended with risk to human beings.