EFFECT OF INTRABRONCHIAL INSUFFLATION OF SOLUTIONS OF SOME INORGANIC SALTS.

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Lamar and Meltzer[1] stated that bronchial insufflation of an isotonic solution of sodium chloride produces no lesion in the lungs. Observations were also made in the course of various experiments carried on by us, which justify the statement that neither hypotonic solutions of sodium chloride nor distilled water causes any pulmonary lesions. In drawing conclusions from these studies the fact should not be forgotten that the posterior part of the lower lobes even of normal dogs frequently shows at autopsy, as previously stated by us,[2] a slight hyperemia when the animals are killed with chloroform.

However, the experience we gathered from the insufflation of sodium hypochlorite caused us to investigate the action of some other inorganic salts in hypotonic and hypertonic solutions. The results are briefly recorded here.

Mercuric Chloride.

Bichloride of mercury was employed in high dilution—1 : 10,000. 5 cc. per kilo of body weight of this solution were insufflated into the bronchi of dogs in the usual manner. At autopsy there was always an unmistakable pulmonary lesion. When the animal was killed after 24 hours the affected lobe of the lung was heavy, dark red in color, and edematous. Microscopically the lesions proved to be largely hemorrhagic in character, and thrombi were present in some of the blood vessels. After 48 hours the hemorrhage and edema were more pronounced, but by the 3rd day the lesion had begun to regress. No bacteria grew in cultures made from the lungs. Obviously the lesion

[1] Lamar, R. V., and Meltzer, S. J., *J. Exp. Med.*, 1912, xv, 133.

[2] Wollstein, M., and Meltzer, S. J., *J. Exp. Med.*, 1913, xvii, 424.

produced by the injection of mercuric chloride directly into the bronchi is not an inflammation; it is merely a hemorrhage which may be so great as to rupture the alveolar walls. This condition is associated with or perhaps caused by thrombosis of the blood vessels.

2 Per Cent Sodium Chloride Solution.

In a series of eight dogs the effect of intrabronchial insufflation of sodium chloride in hypertonic solution (2 per cent equal to about 0.34 M) was tested. 5 cc. of the solution per kilo of body weight were insufflated. Part of the animals were killed 24 hours and others 48 hours after the insufflation. Three of the dogs showed a small area of bronchopneumonia in one lower lobe, while in four others the lungs were practically normal. The eighth animal died soon after the insufflation.

Experiment 1.—December 24, 1917. Black dog, female; weight 5.550 kilos. Received an intrabronchial injection of 28 cc. of sodium chloride, 2 per cent. Killed with chloroform 24 hours later.

Autopsy.—In the right lower lobe there was a wedge-shaped area in the inferior posterior angle measuring 3 by 4 cm. in diameter; it was red, heavy, and swollen.

On section the appearance of the cut surface was that of red bronchopneumonia. Edema and congestion were practically absent from the rest of the lungs.

Microscopic examination proved the lesion to be one of bronchopneumonia, with hemorrhage into some alveoli, and only a small amount of edema.

Experiment 2.—December 24, 1917. Male dog; weight 5.800 kilos. Received intrabronchial insufflation of 30 cc. of sodium chloride, 2 per cent. December 26. Killed with chloroform.

Autopsy.—The right lower lobe contained a wedge in its posterior inferior angle which was not raised, but was dark red in color, and solid.

The cut surface had the appearance of a bronchopneumonia. There was some congestion, but no redness in the other lobes of both lungs.

Microscopic examination showed early bronchopneumonia; the alveoli contained peeled epithelium, red blood cells, granular material, and leukocytes. Other places were more solid, with more leukocytes in the alveoli and infiltrating the walls. The lining cells of the bronchi were normal. There was some periarterial edema.

Experiment 3.—January 3, 1918. Female dog; weight 7.550 kilos. Received intrabronchial insufflation of 38 cc. of sodium chloride, 2 per cent. Killed with chloroform after 24 hours.

Autopsy.—In the posterior inferior angle of the left lower lobe there was a wedge of dark red bronchopneumonia; this area was neither swollen nor heavy; it was

very moist, and the entire lobe was edematous. The right lower lobe contained an area of congestion but no consolidation. Other lobes were normal; there was no pleurisy.

Experiment 4.—January 3, 1918. Male dog; weight 6.300 kilos. Intrabronchial injection of 38 cc. of sodium chloride, 2 per cent. Killed with chloroform after 48 hours.

Autopsy.—The lungs were pink and well aerated.

Experiment 5.—January 8, 1918. Male dog; weight 6 kilos. Intrabronchial injection of 30 cc. of sodium chloride, 2 per cent. Killed with chloroform after 48 hours.

Autopsy.—The lungs showed no consolidation at any point and no edema; very mild congestion.

Experiment 6.—June 17, 1918. Male dog; weight 8.300 kilos. Intrabronchial injection of 40 cc. of sodium chloride, 2 per cent. Killed with chloroform after 48 hours.

Autopsy.—The lungs showed moderate congestion of the right lower lobe. All the other lobes were normal.

Experiment 7.—June 17, 1918. Male dog; weight 9.750 kilos. Intrabronchial injection of 50 cc. of sodium chloride, 2 per cent. Killed with chloroform after 24 hours.

Autopsy.—There was a small amount of congestion in both lungs and in the trachea. Otherwise there were no lesions. Edema was not present.

Experiment 8.—January 18, 1918. Male dog; weight 12.050 kilos. Intrabronchial injection of 60 cc. of sodium chloride, 2 per cent. Found dead after 40 minutes.

Autopsy.—Both lower lobes and the subcardiac lobe were full, heavy, dark red, but translucent. Frothy fluid ran from the trachea.

On section the lungs showed very marked edema, and moderate congestion. There was no bronchitis and no pneumonia. This dog apparently was simply drowned by the intrabronchial injection.

The cultures from the lungs of all the dogs were sterile. Of seven dogs which received intrabronchially the same quantity of a hypertonic solution of sodium chloride, four showed practically normal lungs. The occasional slight congestion observed in these animals may have been due to the use of chloroform in killing them. Three dogs, however, showed lesions. Although the inflammatory area was comparatively small, its bronchopneumonic nature was unmistakable. Attention ought perhaps be called to the fact that these three instances occurred in December and January. It is possible that at this time of the year the lungs are more readily affected by a slight irritant.

As a whole our experiments justify the statement that a hypertonic solution of sodium chloride, administered by intrabronchial injection, causes a comparatively unimportant lesion of the lungs, or none at all.

11 Per Cent Sodium Sulfate Solution.

Five dogs received 5 cc. per kilo of body weight of an 11 per cent solution of sodium sulfate intrabronchially.

Experiment 9.—December 24, 1917. Male dog; weight 6.150 kilos. Received 31 cc. of sodium sulfate, 11 per cent. Killed with chloroform after 48 hours.

Autopsy.—The lungs were well aerated; there were a few small, dark, congested lobules and practically no edema.

Experiment 10.—December 24, 1917. Female dog; weight 7.300 kilos. Received intrabronchial injection of 38 cc. of sodium sulfate, 11 per cent. Killed with chloroform after 48 hours.

Autopsy.—The lungs were pink and well aerated. A few small congested areas were present but there were no consolidation and no edema.

Experiment 11.—January 3, 1918. Female dog; weight 6.700 kilos. Intrabronchial injection of 40 cc. of sodium sulfate, 11 per cent. Killed with chloroform after 48 hours.

Autopsy.—Only the subcardiac lobe was solid with red bronchopneumonia, and some edema. All the other lobes were well aerated.

Experiment 12.—January 3, 1918. Female dog; weight 7.450 kilos. Injected intrabronchially with 48 cc. of sodium sulfate, 11 per cent. Killed with chloroform after 24 hours.

Autopsy.—The right lower lobe contained a wedge-shaped area of bronchopneumonia, rather gray and very moist; there was much edema. No lesion in the other lobes.

Experiment 13.—January 8, 1918. Male dog; weight 8.600 kilos. Intrabronchial injection of 45 cc. of sodium sulfate, 11 per cent. Killed with chloroform after 24 hours.

Autopsy.—The subcardiac lobe was translucent, dark red in color.

On section, it showed bronchopneumonia with plugs of mucus in the bronchi. In the other lobes there was a moderate amount of congestion and edema but no consolidation. A general bronchitis was present. The animal undoubtedly suffered from distemper.

In the first two experiments of this series the intrabronchial injection of a distinctly hypertonic solution of sodium sulfate caused no lesion whatsoever. The last experiment was an instance of distemper. It is not impossible that the dogs in Experiments 11 and 12 were not

normal when the experiment was begun. At any rate, the experiments seem to justify the general statement that an intrabronchial injection of a hypertonic solution of sodium sulfate, like a similar solution of sodium chloride, causes either no pulmonary lesion at all or only an insignificant one.

Magnesium Salts.

A few experiments were made with intrabronchial insufflation of magnesium salts. It should be borne in mind that the intrabronchial use of these salts is fraught with danger. In the first place, it may cause deep anesthesia and paralysis of respiration. The latter could, however, be obviated by intravenous or intramuscular injection of calcium chloride. More serious is the paralytic effect which the magnesium salt may exert upon the heart. Coming directly in contact with the capillaries of the lung, the solution of magnesium salts, without previously being diluted by the blood of the right ventricle, enters the left ventricle and its coronary artery and may thus cause a fatal effect upon the activity of the left ventricle. Two experiments were made with magnesium sulfate and four with magnesium chloride.

Experiment 14. Magnesium Sulfate.—September 12, 1917. 5 cc. per kilo of body weight of hydrated magnesium sulfate, containing seven molecules each of water of crystallization, were introduced intrabronchially. The animal was etherized by intratracheal insufflation and at 10.12 a.m., a cannula was introduced into the jugular vein, to be ready for an injection of calcium chloride. 12 m. 50 cc. of a 6 per cent solution of magnesium sulfate were introduced intrabronchially. 12.27 p.m. The animal was awake but not struggling; placed on the floor. 12.54 p.m. Still recumbent but the head was up. The cannula was removed and the wound stitched. 5 p.m. Still lying down; coughing; temperature 40.2°C. September 13, 9 a.m. No coughing; quiet; temperature 39.3°C. September 14, 9 a.m. Temperature 39.5°C. Condition improved. 11.30 a.m. Killed with chloroform (48 hours after intrabronchial injection of the salt).

Autopsy.—The posterior part of the right lower lobe was half solid, red, swol en, moderately congested, not very heavy, not friable.

The cut surface showed lobular pneumonia, which was confirmed by microscopic examination.

Experiment 15. Magnesium Sulfate.—January 8, 1918. Female dog; weight 10.650 kilos. Injected intrabronchially with 56 cc. of magnesium sulfate, 8.38 per cent, followed by an intramuscular injection in the right thigh of 10 cc. of calcium chloride, 2.5 per cent. January 9, 9 a.m. Animal quiet, lying down;

temperature 39.2°C. January 10, 9 a.m. Temperature 39.5°C.; quiet. 10.30 a.m. Killed with chloroform (about 24 hours after injection of the solution of magnesium sulfate).

Autopsy.—Right lower lobe heavy, swollen, edematous, and congested; not very solid.

The cut surface was mottled with bronchopneumonic areas, especially in the upper part of the posterior border. A moderate amount of congestion was present in the right upper and middle lobes.

Experiment 16. Magnesium Chloride.—January 8, 1918. Male dog; weight 6.850 kilos. 11.44 a.m. Injected intrabronchially with 35 cc. of magnesium chloride, 6.92 per cent (about 5 cc. per kilo), followed by an injection into the right thigh of 10 cc. of calcium chloride, 2.5 per cent. 4 p.m. Temperature 40.1°C. January 9, 9 a.m. Temperature 38.5°C. Animal lively. 10.30 a.m. Killed with chloroform (about 24 hours after injection of magnesium chloride solution).

Autopsy.—The apex of the right upper lobe was solid and swollen; on section very dark areas of hemorrhage alternated with pale red areas of bronchopneumonia. The lower lobe was less solid than the upper; on section it was mottled with areas of bronchopneumonia; there were marked edema and moderate congestion.

Experiment 17. Magnesium Chloride.—June 24, 1918. Female dog; weight 8.150 kilos. Injected intrabronchially with 33 cc. of magnesium chloride, 6 per cent (about 4 cc. per kilo). No rise of temperature followed. The dog was killed with chloroform after 24 hours.

Autopsy.—The right lower lobe contained a firm, dark blue area in the posterior inferior angle, 3 to 4 cm. in diameter. On section, this showed bronchopneumonia with marked edema; the area was red in color and congested moderately. A small amount of frothy fluid in the trachea and the main bronchi.

Experiment 18. Magnesium Chloride.—June 24, 1918. Female dog; weight 14.050 kilos. Given an intrabronchial injection of 56 cc. of magnesium chloride solution, 6 per cent (about 4 cc. per kilo). No rise in temperature followed. June 26, 11 a.m. Animal normal; killed with chloroform (48 hours after injection of magnesium chloride).

Autopsy.—There was a small superficial area of congestion in the left lower lobe about the middle of the posterior border. All the other lobes were well aerated, slightly congested, and not edematous. No frothy fluid in the trachea.

Cultures made from the heart and lungs of the animals intrabronchially injected with magnesium salts showed no growth.

Two more experiments with insufflation of magnesium chloride were made, but they do not belong to this series. They are recorded merely to show the danger of an intrabronchial insufflation of a concentrated solution of a magnesium salt. Through an error a 6 per cent solution of magnesium chloride was prepared from a dehydrated

salt. Without knowing this fact the solution was used on two dogs, giving 4 cc. per kilo. The first dog died a few minutes after the insufflation. The history of the second dog follows:

Experiment 19.—Male dog; weight 12.950 kilos. June 17, 1918, 2 p.m. An intrabronchial injection of 50 cc. of magnesium chloride, about 14 per cent (about 4 cc. per kilo), was given. 2.30 p.m. There was no spontaneous respiration and intratracheal insufflation was started. Froth was emitted from the nose and mouth. Given 30 cc. of calcium chloride, 2.5 per cent, into the muscles of the right thigh. 2.55 p.m. Spontaneous respirations appeared and became regular; lid reflex fair. The insufflation was discontinued, but the tube was left in the trachea for 30 minutes, then removed. 5 p.m. Temperature 37.3°C.; lying down, sick. June 18, 9 a.m. Temperature 39.9°C. 5.45 p.m. Found dead.

Autopsy.—Performed next day. No consolidation in the lungs. The right lower lobe was slightly decolorized and full in the posterior portion. On section, it was congested. Frothy fluid was present in the bronchi. The left lung and the trachea contained no fluid. The 30 cc. of calcium given intrabronchially may have prevented for a time the fatal effect of the magnesium.

From the experiments given above it would seem that magnesium salts are more liable to produce (moderate) pulmonary lesions than sodium salts and that magnesium sulfate may be more effective than magnesium chloride. However, we must bear in mind that the number of experiments in these series is too small to draw definite conclusions from them. For the same reason we shall not attempt to discuss whether this effect of magnesium sulfate upon the lung could be connected with the observation of Gates[3] on the production of hyaline casts by intravenous injections of magnesium sulfate.

SUMMARY.

Intrabronchial injections of isotonic as well as of hypotonic solutions of sodium chloride or even of distilled water cause no pulmonary lesions.

Intrabronchial injections of mercuric chloride even in a dilution of 1 : 10,000 cause a marked pulmonary lesion. The lesion is not of an inflammatory character; it consists of congestion, formation of thrombi, and hemorrhage.

[3] Gates, F. L., *Proc. Soc. Exp. Biol. and Med.*, 1913–14, xi, 102. See also Gates, F. L., and Meltzer, S. J., *ibid.*, 167.

Intrabronchial injections of hypertonic solutions of sodium chloride as well as of sodium sulfate cause, in most instances, no lesions whatsoever. In a smaller number of cases in which moderate lesions were present they may have been due either to a previous infection (distemper) or to some predisposing cause (winter months).

Intrabronchial injection of magnesium salts apparently tends to cause moderate pulmonary lesions (bronchopneumonia). This seems especially true of magnesium sulfate.