

THE REACTION OF THE LUNGS TO THE INTRA-
BRONCHIAL INSUFFLATION OF KILLED
VIRULENT PNEUMOCOCCI AND OF
PLAIN STERILE BOUILLON.*

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In a foregoing communication¹ we reported that the intrabronchial insufflation of a non-virulent strain of pneumococcus produced a lesion which had the gross appearance of a lobar pneumonia. This fact led us to investigate the effects of insufflation of killed virulent pneumococci and of uninoculated sterile bouillon. Both subjects were studied in short series of experiments.

INSUFFLATION OF KILLED VIRULENT PNEUMOCOCCI.

The problem was investigated in a series of ten dogs. A virulent strain of pneumococcus was grown in broth for about twenty hours, and was then killed by heating to 60° C. for fifteen minutes. Control cultures were made and found to be sterile. Doses of fifteen cubic centimeters of killed pneumococci were introduced into the lungs of six dogs; they showed no signs of illness. Only in one animal was there a rise of temperature of 1° C.

One dog was killed twenty-four hours after inoculation. Its lungs showed no pleurisy, and all the lobes were well aerated except the right posterior, which was dark in its posterior third but neither heavy nor swollen. On section this portion of the lung was very moist; thin, frothy fluid ran from the bronchi, and there was a mottled appearance due to the presence of partly solid areas of small size. By an irregular line of congestion this engorged lung substance shaded into the completely normal portion. Microscopic examination showed the lesion to be one of edema and congestion, with some leucocytic exudate in small groups of alveoli. There was

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¹ Wollstein, M., and Meltzer, S. J., *Jour. Exper. Med.*, 1913, xvii, 353.

complete absence of fibrin. Cultures from the heart's blood and lung remained sterile. Smears from the lung showed pneumococci in fair numbers. Evidently some of the injected broth containing the dead but still stainable pneumococci was mixed with the frothy fluid exuding from the bronchi. There was no phagocytosis of the pneumococci.

Two dogs were killed forty-eight hours after insufflation. The lungs showed a patchy congestion in the posterior right lobe besides a small, dark, semisolid area (one centimeter square) near the base of this lobe. Microscopically areas of intra-alveolar leucocytic exudation were found, but there was no fibrin in the alveolar contents. Cocci were still demonstrable in smears, but the cultures remained sterile.

In three dogs, which were killed after three days, the lungs were the seat of superficial areas of congestion in the posterior lobes, with no sign of hepatization. Microscopically there was evidence of phagocytosis of red cells and leucocytes by macrophages. The resolving area was a very small one and no hepatized lobules remained.

Four other dogs received doses of dead cocci enriched three times. Their lungs showed similar lesions of congestion, edema, and very small areas of mild inflammation, the lesions being no more extensive nor severe than those resulting from the smaller doses. A very small amount of fibrin was found in the alveolar exudate of a few lobules, polymorphonuclear leucocytes and small numbers of red cells being present as well. Other alveoli contained granular serum alone or with desquamated epithelium. The lesion bore no resemblance to that produced by living, virulent pneumococci in the same length of time.

These experiments then showed that the lesions produced by intra-bronchial insufflation of killed cultures of virulent pneumococci, still containing stainable organisms, are not similar to the massive pneumonias produced by the insufflation of living pneumococci, but consist of inextensive, mild inflammation of a patchy and superficial character. Mild leucocytic exudation into the alveoli, which also contained a few epithelial cells and some serum, was confined to a few lobules. Fibrin was practically absent. The limited exudates were almost completely absorbed on the third day.

INSUFFLATION OF STERILE BROTH.

In the foregoing experiments the insufflated material contained, besides the broth, substances resulting from the breaking down of some of the pneumococci, and many still morphologically normal, stainable cocci. The question had still to be settled as to the nature of the reaction which the insufflation of sterile broth alone produces. Lamar and Meltzer² stated that insufflation of salt solution, broth, serum, etc., was not followed by consolidation. We give briefly some details of the observations made on a small series of animals receiving, by intrabronchial insufflation, uninoculated sterile bouillon of the kind generally used for cultivating pneumococci.³

The experiments were made on six dogs. Four of the animals received twenty cubic centimeters of broth each; to the other two fifteen cubic centimeters were given. The dogs did not appear to be ill after the insufflation. The larger dose was followed by a rise of temperature of 0.7° C. in two cases, and of 0.8° C. in one other instance; but only in the case of one dog did the temperature remain higher than normal during the day following inoculation.

The lungs of the dogs killed twenty-four hours after receiving the broth looked well aerated and pink. In the posterior lobes there were scattered areas of a darker color, giving the lungs a mottled appearance. These darker portions were elastic and aerated. On section they proved to be congested and very moist, exuding a thin, frothy fluid which was chiefly broth; in no case was there any sign of consolidation. The trachea, bronchi, and lymph nodes were normal in appearance. In one instance the posterior half of the right lung was found to be the seat of an extensive hemorrhage, but no inflammation was present. The pleura had retained its lustre perfectly.

Forty-eight hours after the administration of the broth the posterior lobes were still congested, but there was no evidence of consolidation. The dog whose temperature had remained 0.6° C. above normal showed very small subpleural hemorrhages over all the lobes of the right lung, and the congestion of the lung substance was intense. There was no edema and no hepatization.

²Lamar, R. V., and Meltzer, S. J., *Jour. Exper. Med.*, 1912, xv, 133.

³Lamar, R. V., and Meltzer, S. J., *loc. cit.*, p. 136.

On microscopic examination the capillaries in the alveolar walls as well as the larger blood vessels in the lung framework were found to be distended with red blood cells, of which small numbers had escaped into some of the alveoli. Granular material (serum or broth) was found in many alveoli, and there were several groups of air sacs which contained polymorphonuclear leucocytes. The bronchi and the interlobular septa were quite normal.

Cultures made from the lungs and heart's blood of these six animals remained sterile.

These observations show that sterile bouillon causes a pronounced congestion of the lung tissue with which it comes in contact and that exceptionally it may lead to slight hemorrhage. It brings about a negligible amount of inflammation, visible only on microscopic examination. The congestion may last forty-eight hours. It is possible that some of the bouillon remains unabsorbed for that length of time, thus serving as a continuous irritant.

Since all the animals in these two series of experiments had been killed with chloroform, it seemed advisable to examine the lungs of normal, untreated dogs, killed in the same manner. Such an examination showed that the lungs were pink and aerated, uniformly congested in the posterior lobes, and less markedly congested in the middle and anterior lobes. The trachea, bronchi, and lymph nodes were normal. There was no mottling of the lungs with darker patches, and the lungs contained much less blood than did those of the animals treated with bouillon. On microscopic examination the bronchi were all normal; the capillaries were distended with red cells, some of which were found in the alveoli, together with desquamated epithelium. There was no edema, and no leucocytes had left the blood vessels.

The killing with chloroform causes some degree of congestion in the lungs, more marked in both posterior lobes. However, this congestion is definitely less marked than that which follows the injection of broth and which is confined mostly to the posterior lobe of one lung. We may therefore be quite certain that the essential part of the congestion which was found to exist in one of the posterior lobes twenty-four or forty-eight hours after an intrabronchial insufflation of bouillon was due to the irritation of the bouillon present in that part of the lung and not to the chloroform.

SUMMARY.

The experiments show that intrabronchial insufflation of a culture of virulent pneumococcus killed by heat and still containing stainable organisms produces an inextensive, mild, patchy, super-

ficial inflammation of the lung tissue bearing no similarity to the lesions produced by the living pneumococcus, and that insufflation of sterile bouillon causes a pronounced congestion of the lung tissue with which it comes in contact, sometimes lasting for forty-eight hours.