

SUMMARY AND EVALUATION

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Subject: Study of the effect of brake-drum dust on the lungs of laboratory animals. Of interest and importance.

Evaluation: Taken in conjunction with the paper by J.R. Lynch ("Brake Lining Decomposition Products"), this paper provides effective added refutation to the uninformed speculation that asbestos dust from brake linings might constitute a public health hazard. The present paper shows that brake-drum dust is biologically inert, producing minor, reversible lesions of the lung when injected into the trachea of rats and hamsters. The author comments that the asbestos component of the brake lining has been converted into another substance and is "strictly speaking, not asbestos." Also it is not known "what percentage of the brake-drum dust consisted of the asbestos derivative." He also refers to unpublished data by himself and associates showing that 97 percent of autopsied lungs in Pittsburgh contain so-called "asbestos bodies." However, in 80 percent of these cases only one "asbestos body" was found.

Author: Gross, P.

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Title: "The Pulmonary Response to Brake-Drum Dust: A Preliminary Investigation"

Summary: "Brake-drum dust has evoked a pulmonary response in rats and hamsters which suggest that this dust is biologically 'inert.' Brake-drum dust is capable of producing ferruginous bodies in the lungs of hamsters that are indistinguishable from asbestos bodies."

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Report on

THE PULMONARY RESPONSE

TO

BRAKE-DRUM DUST:

A PRELIMINARY INVESTIGATION

for

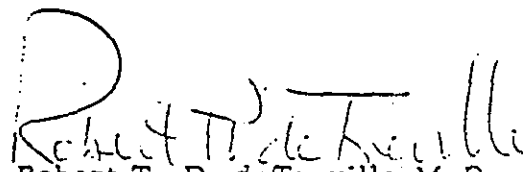
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Introduction

Estimates of the prevalence of so-called "asbestos bodies" in the lungs of non-occupationally exposed adult inhabitants of large urban centers have risen from the original 30% found in Capetown, South Africa, and Miami, Florida, to 97% in Pittsburgh, Pennsylvania,¹⁻⁷ by virtue of greater diligence in searching for these structures and also because of improvements in the method employed. However, even though the prevalence of these bodies in some urban centers may approach 100% of the lungs examined, it is important to bear in mind that in roughly 80% of the lungs, whatever the method employed, only one "asbestos body" was found; and that no increased prevalence of pulmonary fibrosis, lung cancer, or other pulmonary disease was associated with the presence of these bodies.

Thomson, who first discovered these "asbestos bodies" insisted that these structures were proof that urban populations were exposed to a significant asbestos dust hazard which could result in an increased prevalence of asbestotic pulmonary disease. He based his insistence on the assumption that the so-called "asbestos bodies" were a specific response to asbestos fibers. He also indicated ---that likely the most important source of asbestos fibers polluting the urban air was brake-drum dust from automobiles.⁸

Recently, work in this laboratory has established that the so-called "asbestos body" is a non-specific structure that may be formed in response to a number of different fibrous dusts.⁹ The generic term of ferruginous body

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has been proposed for these structures and the specific designation of "asbestos body" has been reserved for those ferruginous bodies in which the central core is known to be an asbestos fiber.

The question of the pathogenicity of brake-drum dust, having been raised, must be resolved inasmuch as the probability exists that such dust may become widely disseminated in urban air.

With this in mind, Dr. Kenneth W. Smith asked the Research Laboratory of the Industrial Hygiene Foundation to undertake a preliminary investigation of the pulmonary response to brake-drum dust.

Method and Materials

Something less than 1 gm of brake-drum dust, said to be free of iron, was furnished by Dr. Smith. This dust was suspended in water so that 1 ml contained 3.5 mg.

In order to study the acute pulmonary reaction to this dust and to compare its acute pathogenicity with that of known fibrogenic and non-fibrogenic dusts, groups of four rats each were injected intratracheally with 1 ml of aqueous suspensions containing the following dusts, respectively: quartz, chrysotile, aluminum silicate, and silicon carbide; all except quartz were fibrous in form. These animals were killed four days after the injection.

For a study of the longer-term pulmonary reaction to brake-drum dust, an additional 10 rats and 12 hamsters were injected intratracheally with this dust. The hamsters received three injections for a total of 10.5 mg, whereas the rats were given six intratracheal injections for a total of 21 mg.

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Three of the hamsters were killed 7 1/2 months after the injection and lung washings were obtained from these animals using a modified LaBelle and Brieger technique. The sediments from these washings were smeared upon slides which were allowed to dry and were examined microscopically unstained.

All remaining hamsters and rats were killed 12 months after the intratracheal dosage.

All lungs were distended with formalin under a pressure of 10 to 12 cm of water. Paraffin sections were cut and stained with hematoxylin and eosin. Pertinent fields on these slides were photographed after which the slides were decolorized and impregnated with silver using Gordon and Sweets technique. The same fields were then rephotographed. The coverslips were then removed and the slides subjected to microincineration for one hour at 600° C. After treatment with concentrated hydrochloric acid and washing with water, the same fields were photographed for a third time, but now under dark-field illumination. By printing through a composite negative, made by superimposing the dark-field negative upon either light-field negative, a picture is obtained that relates the mineral dust to the tissues and cells.

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Results

Acute Reaction

Four days after the intratracheal injection of brake-drum dust, there is proliferation and swelling of alveolar cells and concentration of dust-filled macrophages within alveoli evaginating off alveolar ducts and respiratory bronchioles. Although a few of the alveoli are partially filled by these cells, in general, the air spaces remain widely patent (Fig. 1). The proliferation and swelling of alveolar cells is associated with relatively only slight proliferation of argyrophilic fibers. This is indicated by increased arborescence and by network formation of the axial reticulin of the alveolar walls (Fig. 2).

This reaction is very similar to that observed in rats injected intratracheally with either aluminum silicate or silicon carbide and stands in striking contrast to the reaction observed in rats injected intratracheally with quartz or chrysotile dust. With the latter two dusts, four days after the intratracheal injection, all evaginating alveoli and many of the lumens of alveolar ducts and respiratory bronchioles are filled with inflammatory tissue consisting of argyrophilic stroma and enmeshed histiocytes, macrophages, as well as some leukocytes.

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Longer-term Reaction

A. Seven and one-half months (hamsters)

The lungs of hamsters killed at this time are nearly normal except for widely scattered foci in which a few alveoli contain clusters of macrophages and the lining cells of their septa are excessively numerous and swollen. An occasional giant cell is also found in the air spaces.

Smears of the sediment from the lung washings show scattered asbestos bodies, many of which are segmented (Fig. 3).

B. Twelve months (rats and hamsters)

The only significant lesions found in the lungs of these animals are accumulations of dust-filled macrophages within widely scattered clusters of alveoli, associated with slightly increased arborescence of alveolar argyrophilic fibers (Figs. 4-6). In some instances, the affected alveoli can be identified as ones that were evaginating off alveolar ducts or respiratory bronchioles. No collagenization of alveolar walls or obliteration of alveolar lumens is demonstrable. Also noteworthy is the fact that in rats in spite of a six-fold greater dosage, the amount of alveolar involvement at one year is not greater than that seen at four days with only one dose of 3.5 mg of dust. A similar discrepancy is found in the lungs of hamsters, which also show a degree of pulmonary involvement at one year with a total dosage of 10.5 mg not greater than that of hamsters four days after a single injection of 3.5 mg.

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Comment

The similarity of the four-day lesion to those produced by aluminum silicate and silicon carbide, both recognized to be biologically "inert,"¹⁰⁻¹² suggest that brake-drum dust is also biologically "inert." This suggestion seems to be supported by the pulmonary reaction observed one year after the initial intratracheal injection.

A biologically "inert" dust has recently been defined as one that evokes a pulmonary reaction having the following characteristic features:¹³

1. There is little or no collagenization of the argyrophilic stroma
2. The alveolar architecture is not compromised
3. The lesions are potentially reversible

The pulmonary reaction observed in these animals fulfils all of these criteria. The potential reversibility of the lesions is indicated by the fact that the degree of involvement at one year, despite a three and six-fold greater dosage, is not greater than that seen at four days.

Whether or not the ferruginous bodies caused by brake-drum dust should be called asbestos bodies is open to question inasmuch as the central fiber, strictly speaking, is not asbestos (having lost its water of crystallization during the incorporation of the asbestos fabric in the resin matrix at a very high temperature).

It is not known what percentage of the brake-drum dust consisted of the asbestos derivative; and, therefore, it may be argued that the "inertness" of the

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dust could be ascribed to inadequate dosage. This may be true. However, from a practical point of view, it is not likely that a city dweller is apt to inhale more than an extremely small dose during a 24-hour exposure; and, as seen in these animals, there is no tendency for the lungs to accumulate, compact, and sequester the dust as is seen with certain other dusts.¹⁴ Consequently, removal of the inhaled brake-drum dust from the lungs may be expected to be good.

Nevertheless, it is advisable to repeat this study with a larger number of animals, using also larger dosages and allowing the animals to live out their lives.

Conclusions

Brake-drum dust has evoked a pulmonary response in rats and hamsters which suggests that this dust is biologically "inert."

Brake-drum dust is capable of producing ferruginous bodies in the lungs of hamsters that are indistinguishable from asbestos bodies.

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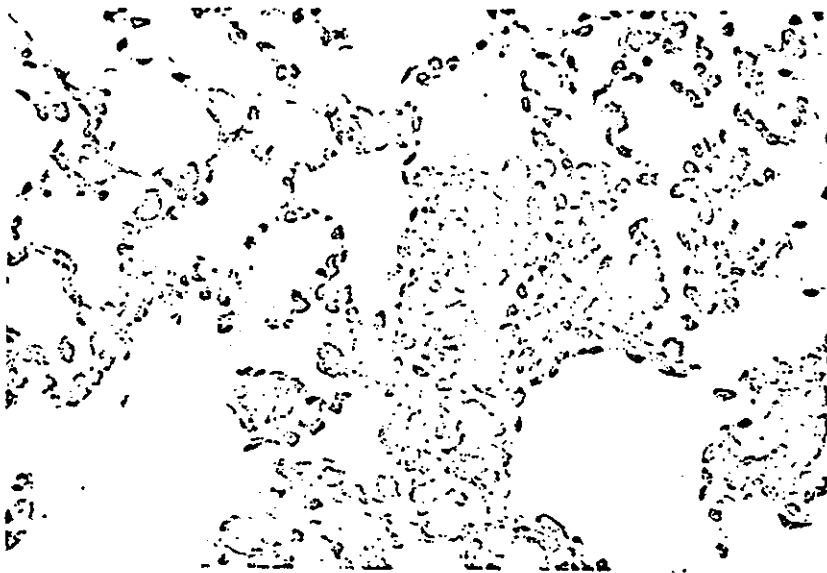


Fig. 1 Region of an alveolar dust four days after an intratracheal injection of brake-drum dust. The "lesion" consists of clusters of macrophages in the evaginating and other nearby alveoli. Hematoxylin and eosin. x 150

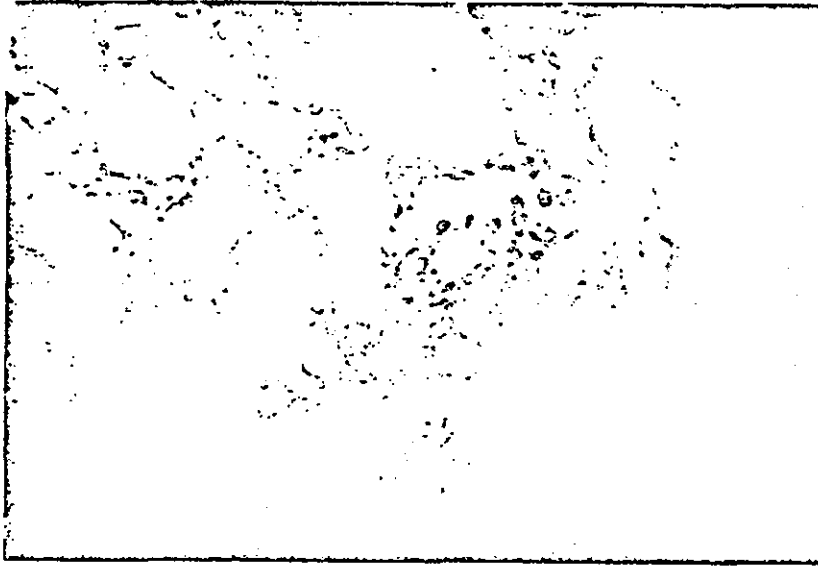


Fig. 2 Composite picture of the same field as in Fig. 1 showing that the dust-filled macrophages contain abundant mineral dust. x 150



Fig. 5 Composite picture of the same field as in Fig. 3 showing that the macrophages still contain abundant mineral dust. x 150



Fig. 6 Smear of lung washings from a hamster injected intratracheally with brake-drum dust seven months previously, showing a typical segmented asbestos body. Eosin only. x1150

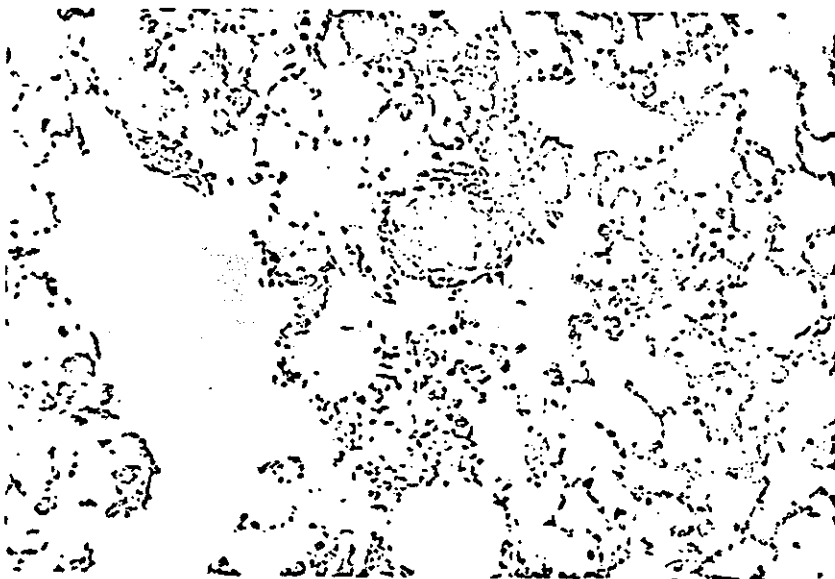


Fig. 3 Region of an alveolar duct one year after intratracheal injections of brake-drum dust. The tissue reaction at this time is not significantly different from that of Fig. 1 and still consists only of clustered macrophages. Hematoxylin and eosin. x 150

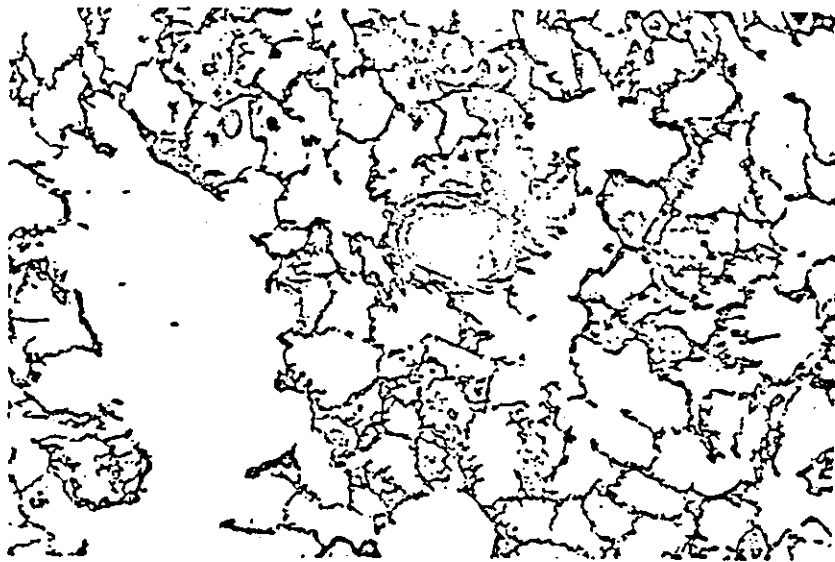


Fig. 4 The same field as in Fig. 3 but after silver impregnation, showing minimal arborescence of mural argyrophilic fibers. Gordon and Sweets. x 150

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