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MR. CHAIRMAN AND MEMBERS OF THE SYMPOSIUM.

I was asked to present a paper on the topic Pulmonary Cancer in the Asbestos Industry, not on account of any special qualifications but because I happen to be in charge of a Clinic which has as its primary function the supervision of the pulmonary condition of some 4,000 asbestos miners; such a group of employees working in a small radius of 5 miles offers an exceptional opportunity to study the problem of cancer of the lung in relation to the inhalation of asbestos fibers.

PRELIMINARY REMARKS.

This question of pulmonary cancer among the asbestos workers is as confusing and obscure as the etiology and the pathogenicity of cancer in general. From 1920 - 1950 the medical literature reports a series of 58 cases of pulmonary cancer and asbestosi Obviously this list must be incomplete but, nevertheless, one could ask is it sound to think that the mere fact of detecting a total of 58 cases of pulmonary cancer during a period of 30 years is sufficient to establish a causal relationship when one realizes that in 1950 an estimated number of 45,000 men were employed in the asbestos industry, and that during that period a minimum of 100,000 employees have inhaled a significant amount of asbestos dust?

It is recognized that the English statistics published in the Annual Report of the Chief Inspector of Factories for the

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See Table

year 1947 seem to indicate a causal relationship between the factor asbestos and pulmonary cancer but, on the other hand, in South Africa with about the same number of asbestos workers as in Great Britain, and when there is also a large number of autopsies and good medical control of all employees in dusty trades, the statistics do not indicate any abnormal incidence of pulmonary cancer.

If the frequency of pulmonary cancer in South Africa and in the Province of Quebec is really not higher amongst the asbestos workers than in any comparable groups as it seems to be, is it possible to suspect that the asbestos mining industry might be different from the Asbestos Textile Industry as far as carcinogenic activity of the asbestos is concerned? The fact that the frequency among the 30,000 asbestos workers of the United States who are also working in the Asbestos Textile Industry is not known to be higher, adds still more to the confusion.

Why is the standardized death rate from cancer of the lungs in Great Britain 3 times higher than that in the United States - 231 in comparison to 723 (rates per million)?

It would indeed be very informative to have some answers to this list of unanswered questions before being able to form an opinion; and it might be that a few answers could influence or modify any conclusion concerning a causal relationship.

PURPOSE OF THIS STUDY.

The purpose of this investigation is to try to learn as precisely as possible the incidence of pulmonary cancer in the group of asbestos mining workers; to know the incidence in groups of employees with severe or insignificant exposure and to know the incidence in groups with or without asbestotic fibrosis.

The Saranac Laboratory and many other investigators were interested in a complete study which would include an epidemiological and an experimental investigation and which would permit to ascertain whether or not a relationship exists between the inhalation of asbestos dust and primary pulmonary cancer. This paper is a preliminary and incomplete report of the epidemiological investigation and the Saranac Laboratory, once the investigation has been achieved, will publish a final report.

METHODS AND MATERIALS.

This study was rendered possible mainly because there exists in Thetford Mines a co-operative industrial clinic where all the employees working in the different asbestos companies are required to have a pre-employment examination, plus an annual periodic examination completed each time by a standard stereogram. At this clinic it was easy to analyse all the medical records, the death certificates, the protocols and the pathological findings of the necropsies and to review the series of chest roentgenograms of each employee. Thetford Mines being a small city of 18,000 it was also easy to contact and to discuss

with the treating physician the nature of any respiratory episode, to have follow-up reports on any suspicious cases and to collect additional details on the cause of the deaths.

In summary, this study is based on the results and findings obtained from the analysis of the medical files of 3,957 employees having worked in the asbestos industry from 2 - 60 years, on the findings from 53 necropsies, on the details collected from the death certificates, on the follow-up reports of cases sent to specialized centers for more complete investigation and diagnosis.

It is possible, and more than likely, that cases of pulmonary cancer have been missed; nevertheless, we think that we have employed a standard procedure in this investigation and that the results therefore are of sufficient interest to make this publication worthwhile.

RESULTS.

Before submitting the results of this investigation, it would seem proper to give a few routine tables in order to reach a better understanding of this communication.

TABLE 1.

POPULATION SAMPLED.

Age group distribution of 3,957 asbestos workers.

AGE GROUPS	15 - 19	20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 & Over	TOT
Number of Employees	76	1113	1091	766	505	307	99	39

This table gives the age group distribution of the sampled population and needs no comment except to mention that the average age of the asbestos workers is somewhat higher than that of the average industrial worker; i.e., 35 in comparison to 33 for most other industrial groups. This remark is logical when we know that the labor turnover in the Quebec Asbestos Mining Industry is about the lowest of all the industries in the whole of Canada. This first table also shows that some 2,000 asbestos workers are 35 years of age and over - a representative group for the study of a cancer problem.

TABLE 2.

Years employed in the asbestos industry
by 3,957 asbestos workers.

Years in the Industry	2 - 4.9	5 - 9.9	10 - 14.9	15 - 19.9	20- 24.9	25- 34.9	35 & Over
Number of Employees	640	1060	645	476	281	546	309
Man - Years	1920	7420	7740	8092	6182	14742	12360

REMARKS: 2,257 men have spent 10 years and over in the asbestos industry.

The second table indicates the number of years spent in the asbestos mining industry by the 3,957 employees studied. Of course this table is not as significant as one indicating the specific exposure for each employee by categories; but after many attempts it has seemed impossible to find a common denominator which would permit to add together the years spent in different degrees of exposure by the same employee.

The man-years exposure has in the mind of many investigators no great meaning in general, but in this case the fact that 56,456 man-years asbestos exposure having given rise to only 10 confirmed cases of pulmonary cancer might indicate that we are not facing an acute problem.

The following table 3 shows classification of various exposures in the asbestos mining industry. I realize that such a classification could be discussed at length and possibly

other dusty industries, it is impossible to translate with a strict mathematical precision the different concentrations of dust particular to each job. This classification is given notwithstanding its limitations because it is based on dust counts performed by different competent agencies and, moreover, because we feel that a satisfactory classification is very useful in understanding more clearly scientific and medico-legal problems.

TABLE 3.

Classification of various exposure in the asbestos mining industry.

Estimated degree of hazard.	Industrial Operations	ATMOSPHERIC CONDITIONS	
		Total dust count M.P.P.C.F. of air sampled.	Percent fiber count
0	Open Pit, Shops	Less than 1	Less than 2
1	Open Pit: Box Loader, Cobber	1 - 3	Less than
	Dump	1 - 3	Less than 2
	Primary Crusher	2 - 3	5
	Dryer	2 - 6	6
	Concentrating	2 - 5	5
	Underground: all jobs under wet condition.		
	Short exposure of skilled employees	3 - 6	1 - 2
2	Open Pit: dry drilling	2 - 5	1 - 2
	Secondary Crushing	10 - 12	4 - 6
	Storage Bin	10 - 14	4 - 6
3	Underground: dry drilling	10 - 15	1 - 3
	Grizzlies	5 - 15	2
	Shed Cobbing	3 - 5	14 - 16
	Shipping Shed: Cleaners, Pilers	4 - 15	10 - 14
4	Mill: Millwrights, Oilers, Sweepers.	10 - 25	25 - 9
	Testers.	8	20
5	Bagging Department	20 - 30	28

This table indicates that the total dust count and the percent fiber count are both constituents of the degree of hazard, meaning that a rather low total dust count may become a risk when the percentages of fibers is high and inversely, that a high total dust count may also become harmless in producing pulmonary fibrosis if the fiber percent count is low.

The percentage of fibers in relation to the total count is calculated for fibers 5 microns and over, and on the principle that only particules having a length at least twice its width are fibers.

As you may see in the table, the industrial operations are grouped in 6 different categories and these categories are again sub-divided by a double line in two main groups. The upper group includes the jobs which in our experience do not produce fibrosis of some clinical importance and the lower group the jobs which can produce asbestosis.

There is an obvious explanation why the men working in the open pit do not develop asbestosis and also why the men working as baggers might develop asbestosis, but it is more difficult to explain why some industrial operations with about the same dust concentration as secondary crushing, storage bin on one part, the grizzlies and shed cobbing on the other part have been classified in different categories. We admit that in adopting such a classification we have been influenced by our clinical findings to some extent, but also by the fact that in the operations of categor 3, the fiber concentration is more constant and work much heavier than in the operations of category 2. There is a marked differenc

in the degree of hazard of categories 1,2 and 4 and 5, but the difference is not so marked for the categories 2 and 3. This table is important in order to fully understand those to follow.

It is true that the main purpose of this presentation is to report the incidence of pulmonary cancer in a group of 3,957 asbestos workers, but the nude statement that 10 cases of pulmonary cancer have been detected would not be significant unless we can compare this prevalence with that in comparable groups.

This task of finding a good comparable group or a control group in this study as in any similar studies is very difficult. We wish it had been possible to find a control group in other industries or in other industrial centers in the Province of Quebec or elsewhere in Canada. We soon realized that no other industries were interested in that problem of cancer of the lungs nor did they have the necessary data for comparison. No other industrial city has ever had two-thirds of its male adult populatio of the same age group so closely medically supervised with a clinical and routine roentgenographic examination as has been done in Thetford Mines for the last 7 years. The mass surveys in different cities did not help the situation; the findings were too dificient doubtless because a too small proportion in the 40-year and over age group is taking advantage of the mass survey. As a matter of fact, a mass survey in Thetford Mines in 1950 by the Provincial Department of Health did not detect a single case of pulmonary cancer as in most of the other centers, and the analys of the results is not very helpful.

It seems probable that the general increase in the frequency of lung cancer is not purely apparent, but when we observe in many cities a sudden and important increase in the lung cancer mortality rates such as the increase in the City of Montreal from 7.7 in 1946 to 12.9 in 1949, we must admit that the medical diagnosis facilities are responsible to an appreciable extent for such an increase. Therefore the exclusive analysis of death certificates in various centers which do not have the same medical facilities, has to be used with caution nor should it be used unless the facilities are comparable. In this study the comparative statistical analysis of the death certificates was not used because in the opinion of the official statistician of the City of Montreal and of the Statistician of the National Cancer Institute of Canada, the death certificates of the asbestos group consisted of a highly selective group and a similar selective group was not available elsewhere.

For all the reasons mentioned above and the fact of being unable to make a better selection, we decided to compare the incidence of pulmonary cancer in different groups of asbestos workers who have been submitted to the same medical investigation, and who at the same time were presenting enough characteristics to permit certain conclusions or impressions.

TABLE 4.

Incidence of pulmonary cancer according to degree and length of exposure by age groups.

	GROUP 1. Unsignificant exposure		GROUP 2. Significant exposure	
	AGE GROUPS		AGE GROUPS	
	16 - 39	40 - 86	16 - 39	40 - 86
Number of Employees	2229	1367	56	305
Prevalence of Pulmonary Cancer	0	6 (0.44%)	0	4 (1.31%)

REMARKS: Unsignificant exposure includes men with exposure 0-1-2 and less than 15 years 3-4-5.

Significant exposure includes only men with more than 15 years 3-4-5. (See Table 3)

The usual calculations of the standard error show that the observed difference in percentages of incidence in the 2 groups (.87) is inferior to twice the Standard Error (1.346).

This table shows that there is no statistical evidence that the incidence of pulmonary cancer in the group 2 including the employees who have sustained severe exposure and all those who have also developed asbestosis, is higher than in group 1 of employees those without significant exposure and without any clinical asbestosis.

It is recognized that this table might lose a large part of its meaning if it is shown that any intensity of asbestos inhalation or any amount of asbestotic fibrosis could be considered as cancerigenic because then a large number of employees in group 1 will be transferred to group 2 and it is probable that an unknown number of pulmonary cancers in the group 1 would also have to be transported to group 2, changing rapidly the observed difference in incidence as well the conclusion.

As a logical complement to this table, we wish we could give a long series of other tables showing the incidence of pulmonary cancer in groups with recent or remote exposure; in groups with gradual exposure of 1-2 to 15 years or a similar exposure of long duration, 15 years and over; also in groups with extensive exposure and asbestosis or without asbestosis.

The data obtained from such tables might tell us in the hypothesis of a causal relationship whether the inhalation of asbestos dust is more important than the presence of asbestosis itself also what approximative degree of asbestos inhalation can be considered as predisposing to cancer.

TABLE 5.

Comparative Incidence of Pulmonary

Cancer in 2 groups of 53 Autopsied asbestos workers.

	GROUP 1.	GROUP 2.	TOTAL
	Employees with Asbestosis	Employees without Asbestosis	
Number Autopsied	34	19	53
Number of Pulmonary Cancer	4	6	10
Percent in Each Group	11.7%	31.5%	

This table shows the prevalence of pulmonary cancer in a series of 53 autopsied asbestos workers having worked in the asbestos mining industry from 17 to 40 years in different degrees of exposure.

This series of autopsies is not as important as the series published in the Annual Report of Great Britain for the year 1947, but can be considered as less selective and more representative in not being composed from cases of asbestosis exclusively but composed of all the employees who happen to be autopsied; although it should be mentioned that there was an

involuntary selection in the sense that most of these employees have been autopsied because they were presenting some respiratory symptoms.

This coincidental selection might explain to some extent the high percentage of cases of asbestosis, but in many instances the amount of asbestotic fibrosis detected was described as minimal and of no clinical importance because not sufficient to produce symptoms.

Because the observed difference in percentages of incidence is inferior to twice the Standard Error, this table does not reveal a statistical evidence of a causal relationship between asbestosis and pulmonary cancer.

Unless we have the opportunity to perform an autopsy on all employees who die, it remains difficult to explain why in our series there are less cases of pulmonary cancer in the asbestotic group and I think we have here a good illustration as to why many statisticians counsel not to draw any conclusions from statistics based on a selective group even if such a group be in the 'autopsy' category because the role played by the factor co-incidence might be too great.

TABLE 6.

Deaths from Pulmonary Cancer as a proportion of deaths from Cancer of all sites. 1940 - 1950

	Number of Cancer All forms	Number of Pulmonary Cancer	Percentages
Province of Quebec	43643	1393	3.2
City of Montreal	15247	918	6.0
City of Quebec	2543	94	3.7
City of Thetford Mines	172	9	5.2

Table 6 was prepared for the purpose of determining if the ratio between the number of cancer deaths all sites and the pulmonary cancer deaths was somewhat different in Thetford Mines from the ratio observed in few other control groups. First it should be mentioned that about 90% of the cases of pulmonary cancer in Montreal and 100% of the cases of the Thetford Group are autopsy cases and both cities have thoracic clinics, so these two groups are reasonably comparable. In Quebec City for the specific period 1945 - 1950 inclusive, 5% of all cancer deaths were also pulmonary cancer. It was thought that had a special factor existed in Thetford Mines the ratio between the number of total cancer and the number of pulmonary cancer would have been different. The difference observed here is not sufficient to draw any conclusion either positively or negatively.

TABLE 7.

Comparative 10 Years Expectancy and 10 Years Prevalence of Pulmonary Cancer in 2 cities.

PLACE	YEARS	10 YEARS EXPECTANCY	10 YEARS PREVALENCE
Thetford Mines	1941 - 1950	10.5	9
Montreal	1941 - 1950	693	856

Based on U.S. Public Health Service Report 2537. A random population of 48,833 giving a year pulmonary cancer expectancy of 7 cases per 100,000 population.

Table 7 was prepared at the suggestion of Dr. Philipps, Statistician for the National Cancer Institute of Canada who thinks that the comparative study of the 10 years expectancy and 10 years actual prevalence of pulmonary cancer in Thetford Mines and in Montreal will be more informative and more conclusive than analysis of the mortality rates. According to the surfey of Dr. Dorn, taking random population of 48,833, an annual incidence of pulmonary cancer of 7 cases per 100,000 can be expected, giving a year expectancy of 7. It is true that Dr. Dorn's survey was made in 1943-45 and that the year expectancy might have increased recently. As a matter of fact, Watson of Saskatoon, Canada, found in 1948 a year expectancy of 8.5; therefore, a year expectancy of 7 is a rather conservative standard.

On that basis Thetford Mines with an average population of 15,000 for 1940 - 1950 period is supposed to have 10.5 cases

of pulmonary cancer, and the actual prevalence is 9 cases. Again it seems logical to think that the 10 year prevalence for pulmonary cancer in Thetford Mines where two-thirds of its adult population is working in the asbestos industry would be higher than the normal 10 year expectancy, should the factor asbestosis be considered carcinogenic.

SUMMARY.

The etiology and the pathogenicity of the pulmonary cancer in relation to asbestos factor is as obscure and confusing as those of cancer in general, and in presence of contradictory data, the many different aspects of the problem should be considered before arriving at a conclusion.

The purpose of this study is to learn the incidence of pulmonary cancer amongst the 3,957 asbestos mining workers and to compare this incidence with other comparable groups. This incomplete epidemiological report is a contribution to a more complete investigation under progress at the Saranac Laboratory.

According to the standard procedure the medical files, the results of medical supervision, the annual stereograms of all the asbestos workers having worked from 2 to 60 years and the findings of 53 autopsies have been used as material.

The results have been tabulated and compared to control groups and we think that the data collected in the Asbestos Mining Industry are not exactly superposable to the results found in the

English Asbestos Textile Industry of Great Britain and if they do not permit to deny a causal relationship between the inhalation of asbestos dust and the occurence of pulmonary cancer, they do not seem either to bring any positive evidence.

Discussion

DR. RHOADS: I was interested in Dr. Cartier's remark that the mass survey employed in his group did not reveal any patients with early pulmonary cancer. I presume that the mass survey was not sufficiently large and therefore this method of revealing a disease which is treatable and often curable may not have been adequate.

In regard to the 53 autopsied individuals, of whom 10 had pulmonary cancer, I presume they were autopsied because it was thought that they may have had pulmonary cancer. Those were not routine autopsies?

DR. CARTIER: No.

DR. RHOADS: The implication is clear that there is no danger from pulmonary cancer to workers in this particular group. Perhaps that inference is true. It appears to me that asbestosis is a very healthy ailment as far as cancer is concerned.

UNIDENTIFIED SPEAKER: Dr. Cariter, what are the first signs of trouble from exposure to asbestos?

DR. CARTIER: I do not believe there are any specific symptoms. If the fibrosis is extensive enough there is dyspnea and cyanosis, sometimes to an extreme degree. In our group we have had 98 cases of asbestosis. These individuals have had a marked exposure to asbestos for years and many of them, on reaching age 50 to 55, are more dyspneic and seem to die more rapidly without much disease. They go downhill rapidly, within a few months.

DR. ROADS: Of what do they die?

DR. CARTIER: Some from cardiac disease and from miscellaneous generalized diseases, some from bronchiectasis. In my experience there is no special picture except that they fail rapidly - in two or three months.

DR. VORWALD: We have been encouraging Dr. Cartier to continue this study of the rather isolated population of Thetford, and we are conducting a similar epidemiological survey of a neighboring community which is also engaged in the mining and processing of asbestos. We suggested to Dr. Cartier that he might determine the incidence of cancer in his exposed group in Thetford by reviewing the chest roentgenograms of his cases - the roentgenograms taken during the past 15 years. Admittedly, cases of pulmonary cancer will be missed by that method. We have considered sputum examinations but at present the best we can do is to study the chest roentgenograms of this large series of individuals exposed in a special industry.

DR. ROADS: Did you discover any cancer cases, in so doing?

DR. CARTIER: Yes, with the X-ray. No cases were revealed by the mass survey; all the cases were detected in the clinic.