FILE NAME: Household Contact (HC)

DATE: 0000

DOC#: HC028

DOCUMENT DESCRIPTION: Unpublished Report Missing Pgs. 1&2 - Mineral Fiber Content of Lung Tissue in Patients with Environmental Exposures: Household Contacts vs. Building Occupants

#353

MINERAL FIBER CONTENT OF LUNG TISSUE IN PATIENTS WITH ENVIRONMENTAL EXPOSURES: HOUSEHOLD CONTACTS vs. BUILDING OCCUPANTS

Victor L. Roggli, M.D.[1]

William E. Longo, Ph.D.[2]

From: Department of Pathology[1]
Durham Veterans Administration and
Duke University Medical Centers
Durham, NC 27710

and

Materials Analytical Services, Inc.[2]
Norcross, GA 30092

criteria were used to establish the diagnosis on tissues obtained either at autopsy (two cases) or surgical resection (two cases) or both (two cases).[10]

Mineral Fiber Analysis. Tissue mineral fiber content was determined using the sodium hypochlorite digestion procedure, the details of which have been reported previously.[14,15] Briefly, formalin-fixed lung parenchyma with a wet weight between 0.25 and 0.35 gm was minced with a clean scalpel blade and digested in 5.25% sodium hypochlorite solution (commercial bleach) with constant gentle agitation. The residue was collected on 0.4μ pore-size polycarbonate filters, one of which was mounted on a glass slide for asbestos body quantification by light microscopy (LM) at 200x magnification. The other was mounted on a carbon disc with colloidal graphite, sputter-coated with gold, and examined by scanning electron microscopy (SEM) at a screen magnification of 1000x.[16] Fibers were defined as particles with an aspect ratio (length: diameter) of at least 3:1 and roughly parallel sides, and particles meeting these criteria and with a length of 5μm or greater were counted. From these data, fiber density on the filter surface and numbers of fibers per filter could be determined. Asbestos bodies and uncoated fibers were enumerated separately, and results reported as asbestos bodies or uncoated fibers 5μm or greater in length per gram of wet lung tissue.[16] In two cases (Cases 9 and 10, Table 2), an additional five gram sample of lung tissue was processed for asbestos body quantification using the technique of Smith and Naylor.[17]

In three cases (Cases 1, 3 and 4, Table 1), only paraffin blocks of lung parenchyma were available for analysis. In these cases, tissue was recovered from the block, deparaffinized in xylene, and rehydrated to 95% ethanol as previously described.[15,18] Digestion was then performed as described above. The filter was cut in half with a scalpel blade, and one half was mounted on a glass slide for asbestos body quantification by LM whereas the other half was mounted on a carbon disc and

examined by SEM. The results were multiplied by a correction factor (0.7) which takes into account the difference in weight between formalin fixed lung and lung which has been processed into paraffin.[15]

The chemical composition of mineral fibers was determined by means of energy dispersive spectrometry in nine of the ten cases. Five to thirty consecutive fibers were analyzed per case and classified as asbestiform (amosite, crocidolite, tremolite, anthophyllite, actinolite, or chrysotile) or nonasbestiform based on their morphology and chemical composition as previously described.[15,16]

Additional studies were performed in one case (Case 8, Table 2) to further characterize the mineral content of lung tissue. Paraffin embedded lung parenchyma was deparaffinized in xylene (three changes, two hours each) and ashed in a low temperature plasma asher for 100 hours. The dry weight of 8 combined specimens in this case was 0.42 gram. After ashing was complete, the remaining residue was suspended in 24 ml of filtered, deionized water and then sonicated for 10 minutes. The suspension was then filtered through a 0.45μ pore-size mixed cellulose ester filter, which was then prepared by the direct method for examination by transmission electron microscopy, selected area electron diffraction, and energy dispersive spectrometry (TEM/SAED/EDS).[19] Also examined with the same methodology was tissue obtained from five women that had died approximately at the same time and in the same institution as Case 8. These women had died from coronary artery disease (two cases), pulmonary embolism, carcinoma of the colon, or cirrhosis (one each). Reagent blanks were also prepared as described above but with tissue omitted.

In addition, a plaster sample was obtained from the high school where case 8 was employed and was analyzed for its mineral content by means of polarized light microscopy with dispersion staining[20] and by TEM/SAED/EDS. Also, the weight percent soluble component was determined by dissolution in a mild hydrochloric acid solution.

RESULTS

The tissue asbestos content of the six household contacts of asbestos workers is summarized in Table 1. All were women with ages ranging from 33 to 73. Three of these patients had pleural mesothelioma and three had lung cancer. One of the latter also had mild asbestosis and one had parietal pleural plaques. Case 5 was a non-smoker. The husband in four cases and the father in one case had worked as asbestos insulators. Each had been diagnosed as having asbestosis and three also had lung cancer. The asbestos body counts among the six household contacts ranged from 2 to 8200 AB/gm, with a median value of 1700 AB/gm. The contents of uncoated fibers (UF) five microns or greater in length ranged from 17,000 to 120,000 UF/gm, with a median count of 24,300 UF/gm. In comparison, our normal range for asbestos bodies as determined in 84 cases with no evidence of asbestos exposure or an asbestos-related disease is 0-20 AB/gm.[15,16,18] The median uncoated fiber count for 20 patients with macroscopically normal lungs at autopsy and no history of asbestos exposure was 3100 UF/gm[16] (and unpublished observations).

The tissue asbestos content of the four building occupants is summarized in Table 2. There were three men and one woman, with ages ranging from 45 to 58. Two of these had pleural mesothelioma, one had peritoneal mesothelioma, and one had adenocarcinoma of the lung. The latter was a non-smoker. All four had either worked or attended school in buildings with asbestos containing materials for periods ranging from 12 to 20 years. The asbestos body counts among the four building occupants ranged from less than 0.2 to 14 AB/gm, with a median value of 1.9 AB/gm. All are within our normal range of 0-20 AB/gm. The content of uncoated fibers five microns or greater in length ranged from 6120 to 25,000 UF/gm, with a median count

of 9680 UF/gm. The latter exceeds the median count of 3100 UF/gm found in our 20 patients with macroscopically normal lungs and no known exposure to asbestos.

The tissue asbestos content in these 10 cases with environmental exposure to asbestos is compared with that of 161 occupationally exposed individuals and 33 with no known occupational exposure in Table 3. It can be seen that in terms of asbestos body concentrations, household contacts rank fourth and have levels that are comparable to those of shipyard workers other than insulators and other asbestos workers (including asbestos cement workers, asbestos textile workers, chemical maintenance workers, welders, machinists, filter manufacturers, roofing plant workers, refinery workers, sheet metal workers, and industrial exposure to asbestos not further specified). Building occupants rank last with regard to asbestos body concentrations, and generally are the same as individuals with no known exposure to asbestos (including textile workers, farmers, military, chemical workers, factory workers, dieticians, guards, musicians, salesmen, barbers, engineers, teachers, tailors, grainmill workers, building contractors, truck drivers, and office workers). Although the ranking by uncoated fiber concentration is slightly different from that for asbestos body content, the former must be considered in light of the types of fibers (asbestiform or nonasbestiform) present as determined by EDS.

The chemical composition of 95 fibers isolated from the lungs of five of the household contacts and 45 fibers isolated from the lungs of the four building occupants is summarized in Table 4. Almost half of the fibers from the household contact cases were the commercial amphiboles, amosite or crocidolite, whereas fewer than 5% of the fibers from the building occupants were commercial amphiboles. On the other hand, almost three fourths of the fibers from the building occupants were nonasbestos mineral fibers,[21,22] mostly talc, silica, rutile, and miscellaneous aluminum silicates. Noncommercial amphiboles and chrysotile accounted for a minority of fibers in both groups (15 to 22%).

Scanning electron microscopic analysis of lung tissue from Case 8 disclosed a substantial number of high aspect ratio fibers with a chemical composition indicative of tremolite. Talc, aluminum silicate, and mica particles with a 3:1 or greater aspect ratio and length of 5μ or more were also identified. Further analysis of lung tissue from this case by analytical TEM confirmed the presence of talc, tremolite, chrysotile, bentonite, and perlite. These constitute five of the seven components identified in the acoustical plaster from the school where this patient was employed (Table 5). No more than two of these seven components were found in the lungs of the five control subjects. Additional particles found in these latter five women's lungs included kaolinite, attapulgite, quartz, and mica.

DISCUSSION

An increased risk of developing an asbestos-related disease has been reported among household contacts of asbestos workers,[2,9] presumably secondary to asbestos fibers brought home on the worker's clothing. However, there have been few reports of the analysis of pulmonary asbestos content among household contacts of asbestos workers. Whitwell et. al.[11] described a case of mesothelioma in the son of a worker from a gas-mask factory where the workers took crocidolite home to pack into canisters. The worker's son was found to have between 50,000 and 100,000 fibers per gram of dry lung tissue as determined by phase contrast light microscopy. (One gram of dry lung tissue is approximately equivalent to 10 grams of wet lung tissue.) Huncharek et. al.[12] reported another case of mesothelioma in the 76 year old wife of a shipyard machinist who dismantled boilers and other shipyard machinery for 34 years. This patient was found to have 6.5 million fibers per gram of dry lung as determined by TEM. The present study indicates that in general, household contacts have substantially elevated pulmonary asbestos burdens, often in the range of individuals who are occupationally exposed to asbestos (Table 3). That the exposures

in these women's homes were heavy is further supported by the observation that in five of the six cases, the occupationally exposed individual in the household was an insulator with clinically diagnosed asbestosis. Three of these individuals also had lung cancer. The median asbestos body and uncoated fiber contents of 30 insulators with asbestosis in the author's series are 109,000 AB/gm and 646,000 UF/gm of wet lung tissue, respectively.

There has been considerable scientific and public debate concerning possible risks of asbestos-induced disease derived from living, working, or attending school in buildings containing asbestos.[1-6] Certainly the measured air fiber levels in buildings using current methods are extremely low,[23] and no adverse health effects have been observed in at least one comparison study of workers in buildings with and without asbestos insulation.[24] However, significant levels of asbestos-contaminated dust are found in these buildings, and routine maintenance activities can disturb this dust producing high concentrations of airborne asbestos.[25] The present study indicates that building occupants have pulmonary asbestos burdens which are quite similar to those of individuals with no known occupational exposure to asbestos (Table 3), and it would be anticipated that their risks for developing an asbestos related disease would be correspondingly low. It should be noted that exposure to asbestos as a building occupant cannot be excluded among the 18 individuals in Table 3 with no known occupational exposure to asbestos. However, we have no reason to believe that these individuals are anything other than representative of the background, "non-exposed" population for our area. Furthermore, not all mesotheliomas are related to asbestos exposure, as spontaneous cases do occur[11] as well as a few rare cases due to causes other than mineral fibers.[26]

There is a single case report in the literature of pleural mesothelioma developing in an individual whose only known exposure to asbestos was as an office worker in a building with asbestos containing materials (ACM).[13] This was a 54 year

old woman who worked for many years in a building with ceiling mater
of 70% amosite asbestos. Analysis of her lung tissue demonstrated 31
per gram of dry lung by TEM, the vast majority of which were found t
asbestos by EDS.[13] Our case 8 demonstrated an unusual number of hi
tremolite fibers within her lung parenchyma (Tables 2 and 5). Tremol
recognized cause of pleural mesothelioma, accounting for about 20%
according to the study by McDonald et. al.[27] Since multiple compone
acoustical ceiling plaster from the building in which this patient work
found in her lung tissue samples, this is the most likely source of the
asbestos fibers which were identified. There was no evidence of exp
cosmetic talc and no evidence of household exposure based on the hu
occupational history. Furthermore, the presence of histologically cc
pleural plaques is compelling evidence that this woman's pleural mes
indeed asbestos related. Additional studies are necessary in order t
whether such cases as these occur with sufficient frequency to be o

SUMMARY

Analysis of tissue mineral fiber content in patients with envir
exposures has seldom been reported in the past. Our studies of six
of asbestos workers indicate that these individuals often have pulm
concentrations similar to some occupationally exposed individuals.
studies of four occupants of buildings with asbestos containing mat
these individuals often have pulmonary asbestos burdens indistingu
general non-occupationally exposed population. However, one suc
exposed for many years who later developed pleural mesothelioma
detail, and it was concluded that her exposure as a teacher's aide
containing acoustical plaster was the likely cause of her mesothe

REFERENCES

1. Bohlig, H. & E. Hain. 1973. Cancer in relation to environmental exposure, *In* Biological Effects of Asbestos. P. Bogovski, V. Timbrell, J.C. Gilson, & J.C.Wagner, Eds. IARC Scientific Pub. No. 8, Lyon, France: 217-221.
2. Anderson, H.A., R. Lilis, S.M. Daum, & I.J. Selikoff. 1979. Asbestosis among household contacts of asbestos factory workers. Ann. N.Y. Acad. Sci. **330**:387-399.
3. Neuberger, M., M. Kundi, & H.P. Friedl. 1984. Environmental asbestos exposure and cancer mortality. Arch. Environ. Health **39**:261-265.
4. McDonald, J.C. 1985. Health implications of environmental exposure to asbestos. Environ. Health Persp. **62**:319-328.
5. Davis, J.M.G., & J.C. McDonald. 1988. Low level exposure to asbestos: Is there a cancer risk? Br. J. Ind. Med. **45**:505-508.
6. Mossman, B.T., J. Bignon, M. Corn, A. Seaton, & J.B.L. Gee. 1990. Asbestos: Scientific developments and implications for public policy. Science 247:294-301.
7. Wagner, J.C., C.A. Sleggs, & P. Marchand. 1960. Diffuse pleural mesothelioma and asbestos exposure in the North Western Cape Province. Br. J. Ind. Med. 17:260-271.
8. Antman, K.H. 1980. Malignant mesothelioma. N. Engl. J. Med. 303:200-202.
9. Newhouse, M.L., & H. Thompson. 1965. Mesothelioma of pleura and peritoneum following exposure to asbestos in the London area. Br. J. Ind. Med. 22:261-269.
10. Roggli, V.L., J. Kolbeck, F. Sanfilippo, & J.D. Shelburne. 1987. Pathology of human mesothelioma: Etiologic and diagnostic considerations. Pathol. Annu. **22(2)**:91-131.

11. Whitwell, F, J. Scott, & M. Grimshaw. 1977. Relationship between occupations and asbestos fibre content of the lungs in patients with pleural mesothelioma, lung cancer, and other diseases. Thorax 32:377-386.

12. Huncharek, M, J.V. Capotorto, & J. Muscat. 1989. Domestic asbestos exposure, lung fibre burden, and pleural mesothelioma in a housewife. Br. J. Ind. Med. 46:354-355.

13. Stein, R.C., J.Y. Kitajewska, J.B. Kirkham, N. Tait, G. Sinha, & R.M.Rudd. 1989. Pleural mesothelioma resulting from exposure to amosite asbestos in a building. Respir. Med. 83:237-239.

14. Roggli, V.L., & A.R. Brody. 1984. Changes in numbers and dimensions of chrysotile asbestos fibers in lungs of rats following short-term exposure. Exp. Lung Res. 7:133-147.

15. Roggli, V.L., P.C. Pratt, & A.R.Brody. 1986. Asbestos content of lung tissue in asbestos-associated diseases: A study of 110 cases. Br. J. Ind. Med. 43:18-28.

16. Roggli, V.L. 1989. Scanning electron microscopic analysis of mineral fibers in human lungs, Chptr. 5, *In* Microprobe Analysis in Medicine. P. Ingram, J.D. Shelburne, & V.L.Roggli, Eds. Hemisphere Pub. Corp: Washington, D.C.: 97-110.

17. Smith, M.J., & B. Naylor. 1972. A method of extracting ferruginous bodies from sputum and pulmonary tissue. Am. J. Clin. Pathol. 58:250-254.

18. Roggli, V.L., M.H.McGavran, J.A. Subach, H.D. Sybers, & S.D. Greenberg. 1982. Pulmonary asbestos body counts and electron probe analysis of asbestos body cores in patients with mesothelioma: A study of 25 cases. Cancer 50:2423-2432.

19. Churg, A. 1989. Quantitative methods for analysis of disease induced by asbestos and other mineral particles using the transmission electron microscope, Chptr. 4, *In* Microprobe Analysis in Medicine. P. Ingram, J.D.

Shelburne, & V.L. Roggli, Eds. Hemisphere Pub. Corp: Washington, D.C.: 79-95.

20. McCrone, W.C. 1979. Evaluation of asbestos in insulation. Am Lab 11:19-31.

21. Churg, A. 1983. Nonasbestos pulmonary mineral fibers in the general population. Environ. Res. 31:189-200.

22. Roggli, V.L. 1989. Nonasbestos mineral fibers from human lungs. Microbeam Analysis - 1989. Russell, P.E., Ed.. San Francisco Press, Inc: San Francisco: 57-59.

23. Crump, K.S., & D.B. Farrar. 1989. Statistical analysis of data on airborne asbestos levels collected in an EPA survey of public buildings. Reg. Toxicol. Pharmacol. 10:51-62.

24. Cordier, S., P. Lazar, P. Brochard, J. Bignon, J. Ameille, & J. Proteau. 1987. Epidemiologic investigation of respiratory effects related to environmental exposure to asbestos inside insulated buildings. Arch. Environ. Health 42:303-309.

25. Keyes, D., R. Hatfield, W.E. Longo, J. Millette & J. Chession. 1990. Recent research on fiber release from ACM and re-entrainment of asbestos dust. Proceedings of the National Asbestos Council, Feb. 1990, San Antonio, TX.

26. Peterson, J.T., S.D. Greenberg, & P.A. Buffler. 1984. Non-asbestos-related malignant mesothelioma: A review. Cancer 54:951-960.

27. McDonald, J.C., B. Armstrong, B. Case, D. Doell, W.T.E. McCaughey, A.D. McDonald, & P. Sébastien. 1989. Mesothelioma and asbestos fiber type: Evidence from lung tissue analyses. Cancer 63:1544-1547.

TABLE 1. Demographic, Pathologic, and Exposure Information and Asbestos Content of Lung in Six Household Contacts of Asbestos Workers

Case No.	Age/Sex	Exposure	Diagnosis	AB/gm (LM)	UF/gm (SEM)
1	62/F	Wife of shipyard insulator with asbestosis, 29 yr.	Pleural mesothelioma	8200	ND
2	33/F	Daughter of insulator with asbestosis, 25 yr.	Pleural mesothelioma	2330	17,000
3	63/F	Wife of insulator with asbestosis and lung cancer, yrs.	Small cell/large cell ca; lung, mild asbestosis	3670	120,000
4	59/F	Wife of insulator with asbestosis and lung cancer, 23 yrs.	Small cell ca., lung, PPP	1060	57,000
5	73/F	Wife of insulator with lung cancer and asbestosis, yrs.	Bronchioloalveolar cell ca., LUL	400	23,700
6	57/F	Wife of shipyard worker, 1-2 yrs.	Pleural mesothelioma	2	24,300

AB/gm (LM) = asbestos bodies per gram of wet lung as determined by light microscopy; UF/gm (SEM) = uncoated fibers 5μ or greater in length per gram of wet lung as determined by scanning electron microscopy; PPP = parietal pleural plaques; LUL = left upper lobe; ca. = carcinoma; ND = not done.

TABLE 2. Demographic, Pathologic, and Exposure Information and Asbestos Content of Lung in Four Occupants of Buildings with ACM

Case No.	Age/Sex	Exposure	Diagnosis	AB/gm (LM)	UF/gm (SEM)
7	46/M	Worked in building with ACM, 20 yr.	Adenocarcinoma, lung	14	25,000
8	58/F	Teacher in building with ACM, 18 yr.	Pleural mesothelioma, PPP	2.8	13,000
9	45/M	Attended school containing asbestos, 12 yr.	Peritoneal mesothelioma	1.0	6120
10	53/M	Accountant in building with ACM, 18 yr.	Pleural mesothelioma	<0.2	6370

AB/gm (LM) = asbestos bodies per gram of wet lung as determined by light microscopy; UF/gm (SEM) = uncoated fibers 5μ or greater in length per gram of wet lung as determined by scanning electron microscopy; PPP = parietal pleural plaques; ACM = asbestos containing materials.

TABLE 3. Asbestos Content of Lung Tissue by Exposure Category*

	N	AB/gm (LM)	UF/gm (SEM)
Insulators	59	20,400	224,000
Shipyard Workers (other than insulators)	60	3600	37,000
Other Asbestos	24	2360	68,800
Household Contacts	6	1700	24,300
Railroad Workers	10	55	28,800
Brakeline work or repair	8	50	15,400
Manual Laborer	15	20	8830
Other	18	2.9	2910
Building occupants with ACM	4	1.9	9680

* Data presented as median values. For other abbreviations, see footnotes to Tables 1 and 2

TABLE 4. Energy Dispersive Spectrometry of Fibers in Patients with Environmental Exposures

	N	Commercial Amphiboles*	Non-Commercial† Amphiboles	Chrysotile	Other‡
Household Contacts	5	46 (48%)	10 (10.5%)	4 (4.2%)	35 (37%)
Building Occupants	4	2 (4.4%)	9 (20%)	1 (2%)	33 (73%)

* Commercial amphiboles = amosite and crocidolite

† Non-commercial amphiboles = tremolite, anthophyllite, and actinolite

‡ Other includes talc, silica, rutile, aluminum silicates, miscellaneous silicates, iron, and iron-chromium

TABLE 5. TEM/SAED/EDS Data Regarding Particulate Content of Lung in Case 8 as Compared to Five Control Subjects and Plaster from Building

	Chrysotile	Tremolite	Perlite	Talc	Bentonite	Calcite	TiO_2
Plaster	+	+	+	+	+	+	+
Case 8	+	+	+	+	+	-	-
Control A	+	-	-	+	-	-	-
Control B	-	+	-	-	-	-	-
Control C	-	-	-	-	-	-	-
Control D	-	+	-	-	-	-	-
Control E	-	-	+	+	-	-	-

+ = Present; - = Not detected