資料 3

Françoise Galateau-Sallé

Pathology of Malignant Mesothelioma

With 169 Figures, 158 in Full Color

International Mesothelioma Panel
Elisabeth Brambilla, Philip T. Cagle, Andrew M. Churg,
Thomas V. Colby, Allen R. Gibbs, Samuel P. Hammar, Philip S. Hasleton,
Douglas W. Henderson, Kouki Inai, Marleen Praet, Victor L. Roggli,
William D. Travis, Jean Michel Vignaud

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1
Epidemiology of Mesothelioma

Malignant mesothelioma has risen from obscurity and rarity during the first half of the twentieth century to become a major occupational and public health problem late in the latter half of that century and the beginning of the twenty-first century. The nexus between asbestos exposure and subsequent development of mesothelioma was established definitively in 1960 by Wagner et al. [1] in South Africa. By the late 1990s, the incidence of mesothelioma in some industrialized nations was roughly comparable to that of cancer of the larynx [2], and the mortality rate was similar to that for renal cell carcinoma in men and for uterine cancer in women [2–4]. Apart from lung cancer, mesothelioma constitutes the most important occupational cancer among industrial workers.

Most mesotheliomas encountered during the early twenty-first century are a consequence of prior occupational exposure to asbestos from the 1940s through the 1970s, including end-use and bystander exposures [5, 6]. The relation between inhalation of asbestos fibers—especially one or more of the amphibole varieties—and mesothelioma is accepted by almost all authorities as causal; because of the consistency and specificity of the asbestos-mesothelioma relation, the incidence of mesothelioma is usually considered to be an index of societies' past usage of asbestos (Table 1.1) [7–10].

Recent incidence rates for mesothelioma in various countries are listed in Table 1.1 and are generally in the range of 14 to 30 cases per million persons per year (>15 years of age) [9, 10]. The highest incidence is found in Australia, where the rate in 1997 was 29.8/million persons/year (50.6/million/year for males and 9.0/million/year for females, standardized to the world population >20 years of age, whereas the corresponding crude rates in 1997 for Australia were 59.8/million for males and 10.9/million for females) [4]. In the United States, the current rate for the sexes combined is 10.0/million/year [11].

It has been estimated that about 10,000 mesotheliomas occur annually throughout North America, Australia, and seven nations in western Europe and Scandinavia [9]. Peto et al. [5] predicted about 190,000 mesothelioma

TABLE 1.1. Mesothelioma incidence across nations relative to historical use of asbestos*

Nation	Mesothelioma incidence (cases/million/year)	Use of asbestos (kg/capita/year)
Australia (1995)	33	4.4 (1968)
The Netherlands (1995)	27	3.4 (1976)
United Kingdom (1991)	23	2.7 (1970)
Italy (1993)	22	2.5 (1975)
France (1996)	17	2.6 (1970)
Finland (1995)	15	2.2 (1970)
Germany (1997)	15	3.0 (1975)
Sweden (1995)	15	2.4 (1970)
United States (1999)	10	2.3 (1975)
Norway (1995)	14	1.9 (1970)

Modified from Tossavainen [9].

deaths across six nations in western Europe (Britain, France, Germany, Italy, The Netherlands, and Switzerland) over the 35-year period dating from 1999. Modeling of data for France indicates that mortality from mesothelioma among French men aged 50 to 79 will continue to increase, reaching a peak of 1140 deaths in 2030 (optimistic forecast) to 1300 deaths in 2040 (pessimistic prediction), and no preventive measures implemented at this time can affect this trend [12]. In Australia, the incidence of mesothelioma is expected to peak in about 2020 (approximately 18,000 cases for the period 1945–2020) [4]. In the United States, the peak incidence was predicted to occur by the year 2000, with a slow decline thereafter [7]. In the United Kingdom, the rate of increase in mesothelioma-related deaths slowed slightly in 1997, when there were 1330 deaths, but the rate increased thereafter, with 1535 deaths in 1998 and 1595 in 1999 [13]; the crude death rate for mesothelioma in Great Britain rose from 29.57 per million for males during 1989–1991 to 40.93 during 1995–1997, and for the same periods the equivalent death rate in females rose from 4.67 to 5.77 [14]. The Health and Safety Executive [15] estimated that deaths from mesothelioma in men in the United Kingdom "may peak around the year 2011, at about 1700 deaths per year," whereas mesothelioma-related deaths in women "are running at about one-sixth of the level in men." In this respect, mesothelioma incidence rates have increased about fourfold or fivefold in Australia over a period of almost 20 years, and the rate in females has also increased about threefold; however, the male incidence is more than five times that in females [4]. In some nations, the time trend of increasing incidence after 1986 is restricted largely to those aged over 50 years, suggesting that controls on occupational exposures introduced from the 1970s have been effective [4]. However, this is not the case for all industrialized countries. In France, for instance, the relative risk of developing a pleural mesothelioma among men is 1.83 for the youngest

generation (men born in 1953) compared to the 1928 generation [16], whereas the maximum risk for males occurs for the 1925–1929 birth cohort in the United States [17]. These contrasting findings show that awareness about the danger of asbestos exposure effects was not the same in all countries.

Asbestos Exposure and Mesothelioma

In national registries, about 90% of male mesothelioma patients have a history of asbestos exposure, especially those with pleural mesotheliomas, with a somewhat smaller percentage for patients with peritoneal mesothelioma (about 60%) [4, 18]. The proportion of asbestos-associated mesotheliomas is lower in females and varies among countries, ranging from 25% in the United States to as much as 70% in Australia [4, 18]. In some series a small number of the exposures are occupational, so nonoccupational exposures comprise a much larger proportion of mesothelioma cases among women [19]. Roggli et al. [19] found that the lung tissue asbestos burden was elevated in 70% of a series of female mesothelioma patients in the United States: the main fiber type was amosite, followed by tremolite.

The occupations producing the greatest number of mesotheliomas have changed over the years from miners/millers and those involved in product manufacture and insulation work to other end-users of asbestos-containing products, most notably persons in building construction and demolition industries and in shipyards [6–8, 13, 20], in part because working conditions in the building industry in particular have been poorly regulated. Individual life-time risks of mesothelioma are highest among crocidolite miners/millers, power station workers, railways laborers, and naval, merchant naval, and shipyard personnel [4]. However, the number of personnel employed in each of the last-cited occupations are smaller than in the building construction industry, so carpenters/joiners, for example, contribute greater absolute numbers to national mesothelioma tolls, although the individual risk is less [4]. Substantial numbers of mesotheliomas are now seen as a consequence of nonoccupational exposures, including occasional "handyman"-type exposure, domestic exposure (e.g., from laundering asbestos-contaminated work clothes), and other types of occasional or nonoccupational exposures [4, 6, 21, 22]. Mesothelioma has been reported to occur after brief low-level or indirect exposure [23].

The risk or incidence of mesothelioma shows a dose-response relation to cumulative asbestos exposure, so the risk is greatest with heavy exposures [24, 25], and peritoneal mesotheliomas [26] are usually related to heavier cumulative exposures than pleural mesotheliomas. In general, the incidence of mesothelioma in asbestos-exposed cohorts reflects the fiber type or types, cumulative exposure, and the time following exposure so remote exposures

are more significant for mesothelioma induction than recent exposures, other factors being equal [24].

Asbestos occurs in two major mineralogic groups: the amphiboles (of which amosite and crocidolite constitute the major commercial forms) and chrysotile [27]. Over recent decades, chrysotile comprised about 95% of world asbestos production, most originating from Canada and Russia [6]. Fibrous tremolite, anthophyllite, and actinolite constitute other forms of amphibole asbestos. Production of these minerals, however, was restricted to only a few mines or industries, although small amounts of fibrous tremolite occur in Canadian chrysotile (usually about 1% or less), and tremolite was used in certain regions (e.g., as a whitewash in Greece and Cyprus and in New Caledonia) [6]. Although it has been claimed that all varieties of commercial asbestos have the capacity for mesothelioma induction, there is general agreement that crocidolite is the most potent type of asbestos for mesothelioma induction, followed by amosite and then chrysotile [6, 28]. There is much debate regarding the ability of chrysotile to cause mesothelioma. Some of the differences relate to interpretation of the epidemiologic data, but at the heart of the controversy lie the differing views on the importance of biopersistence in carcinogenesis and the significance of chrysotile contamination by tremolite. The association between mesothelioma and chrysotile exposure is largely based on studies of the Quebec chrysotile miners and millers, a situation where tremolite contamination of the chrysotile ore is well recognized [29, 30]. It is outside the scope of this volume to debate this issue, and the reader is referred elsewhere [28–38]. The greater potency of the amphiboles for mesothelioma induction compared to that of chrysotile is thought to be related to the fiber characteristics and to the greater biopersistence of amphibole fibers in lung tissue than chrysotile (which fragments or dissolves more rapidly), so the half-life of chrysotile (weeks to months) in lung parenchyma is much shorter than the half-life for the amphiboles (years to decades) [6, 38]. The factors influencing fiber clearance from the lung were well summarized by Roggli and Brody [39].

Fiber dimensions are also thought to be important for mesothelioma induction, so short-length fibers have little carcinogenic activity in comparison to long-length fibers (>5 μm in length and especially >8–10 μm in length) [6, 40]. Boutin et al. [41] demonstrated asbestos fibers concentrated in parietal pleural "black spots" in exposed subjects. Amphiboles outnumbered chrysotile in all samples: 22.5% of fibers were 5 μm or longer in the black spots. The black spots were histologically similar to milky spots as seen by conventional and electron microscopy. These findings may well explain why the parietal pleura is the target organ for mesothelioma and plaques.

Most mesotheliomas now encountered among the populations of Europe, North America, and Australaia occur in individuals with a history of mixed asbestos inhalation (e.g., chrysotile plus amosite fibers released by

operations on insulation materials or high-density asbestos-cement building products) [6].

It should be remembered that a history of exposure to asbestos or the lack thereof is important when assigning causation to a malignant mesothelioma. However, a history of exposure to asbestos should play no role in the diagnosis; diagnosis depends on the gross, microscopic and special-technique observations, as it does with any other tumor.

Latency

There is characteristically a prolonged time interval (i.e., latency) between the first inhalation of asbestos and the subsequent diagnosis of mesothelioma, generally in the range of 20 to 40 years [37]. For most mesotheliomas, the latency is more than 20 years, with 15 years or less for only about 1% of mesotheliomas [13, 42–44]; some authorities delineate a minimum lag-time of 15 years from exposure and others 10 years [43]. When the latency is less than 10 to 15 years, it is likely that the proximate exposure was coincidental and that there were one or more unrecognized exposures more remote in time [38].

Other Factors Implicated in the Induction of Mesothelioma

Despite strong association with past asbestos exposure, there are other mesotheliomas for which the cause is unknown [45].

Erionite is a naturally occurring fibrous zeolite and is known to induce mesothelioma among the inhabitants of certain villages in the Cappadocian region of Turkey [46–48]. Erionite has fiber dimensions and properties similar to those of amphibole forms of asbestos.

There are anecdotal reports of mesothelioma following *irradiation*, including radiotherapy for childhood cancers such as Wilms' tumor; cases of mesothelioma have also been reported following injection of radioactive thorium dioxide (Thorotrast) for radiologic investigations (for references, see elsewhere [22–49]). However, a retrospective cohort study on a large group of women with breast cancer and patients with Hodgkin's disease—many of whom had been treated by radiotherapy—found no significant increase in the relative risk of mesothelioma [50]. In addition, coexisting asbestos exposure represents a confounding factor for some cases associated with irradiation: In one report on mortality among plutonium workers, all the mesotheliomas occurred in patients who had also sustained asbestos exposure [51]. The incidence of mesothelioma was not increased (as a second malignancy) in one study of patients with prior radiation therapy [52].

Prior Inflammatory Disorders Affecting Serosal Membranes

Mesotheliomas have occurred years after chronic inflammatory lesions of the pleura (e.g., chronic empyema or packing of the pleural cavity with lucite spheres as treatment for tuberculosis (plombage therapy)), and there are a few reports (about eight 8 cases) of an association with familial Mediterranean fever (FMF), possibly related to recurrent FMF serositis [53]. However, cases of this type are exceptional. For example, in relation to FMF, cases of mesothelioma have been reported in the Mediterranean region after white-washing homes with tremolite-containing material [54, 55]. Most cases of "postinflammatory" mesothelioma with a short interval between inflammation and tumor are probably mesotheliomas that presented with a burst of inflammatory activity followed by a period of quiescence [56].

Simian Virus 40 and Mesothelioma

A voluminous literature has grown rapidly on the detection of simian virus 40 (SV40) DNA in up to 60% of human mesotheliomas (see Chapter 2). These reports followed an initial observation that SV40 induces mesothelioma in experimental animals when injected into the pleural cavity [57]. For humans, early poliomyelitis vaccines contaminated with SV40 were a potential source for the SV40 DNA. However, the evidence in favor of SV40 as a cofactor for mesothelioma induction is still inconclusive, and a recent position statement from the British Thoracic Society evaluated the evidence for this relation as "weak" [58].

Familial Factors

The clustering of mesothelioma within families has been reported in several articles, which has suggested a genetic susceptibility to the tumor [59]. Some have occurred in the apparent absence of asbestos exposure, whereas others have also been associated with asbestos exposure. However, the genetic and biologic differences between asbestos-related and non-asbestos-related tumors are unclear [60]. A recent report described a family of three sisters who developed mesothelioma in association with environmental-residential exposure to asbestos; in two of the cases, comparative genomic hybridization showed a loss only at 9p; and it was suggested that this region might be a site of one or more oncosuppressor genes, which might be related to increased genetic susceptibility to the carcinogenetic effects of asbestos [61].

References

1. Wagner JC, Sleggs CA, Marchand P. Diffuse pleural mesothelioma and asbestos exposure in the North Western Cape Province. Br J Ind Med 1960;17:260–71.

2. South Australian Cancer Registry. Epidemiology of cancer in South Australia: incidence, mortality and survival 1977 to 1999. Adelaide: Department of Human Services; 2000.
3. New South Wales Cancer Council (NSWCC). Cancer in New South Wales: incidence and mortality 1997. Sydney: NSWCC; 1999.
4. Leigh J, Davidson P, Hendrie L, Berry D. Malignant mesothelioma in Australia, 1945–2000. J Occup Health Safety Aust NZ 2001;17:453–70.
5. Peto J, Decarli A, La Vecchia C, et al. The European mesothelioma epidemic. Br J Cancer 1999;79:666–72.
6. World Trade Organization (WTO): European Communities—measures concerning asbestos and asbestos-containing products. Geneva: WTO; 2000 (www.wto.org).
7. Price B. Analysis of current trends in United States mesothelioma incidence. Am J Epidemiol 1997;145:211–18.
8. Teschke K, Morgan MS, Checkoway H, et al. Mesothelioma surveillance to locate sources of exposure to asbestos. Can J Public Health 1997;88:163–8.
9. Tossavainen A. Asbestos, asbestosis and cancer: exposure criteria for clinical diagnosis. In: People and Work Research Reports, vol 14. Helsinki: Finnish Institute of Occupational Health 1997;14:8–27.
10. Tossavainen A, Takahashi K. Epidemiological trends for asbestos-related cancers. In: People and Work Research Reports, vol 36. Helsinki: Finnish Institute of Occupational Health 2000;36:26–30.
11. Price B, Ware A. Mesothelioma trends in the United States: an update based on Surveillance, Epidemiology, and End Results Program data for 1973 through 2003. Am J Epidemiol 2004;159:107–12.
12. Banaei A, Auvert B, Goldberg M, et al. Future trends in mortality of French men from mesothelioma. Occup Environ Med 2000;57:488–94.
13. Health & Safety Executive (HSE). Health and safety statistics 2000/01. London: HSE Books; 2001 (http://www.hse.gov.uk/statistics/2001/hsspt2.pdf).
14. HSE. Health and Safety Statistics 1998/99. London: HSE Books; 1999.
15. Health and Safety Executive. Mesothelioma Occupation Statistics: male and female deaths aged 16–74 in Great Britain: 1980–2000 (excluding 1981). Available on the HSE website 2003.
16. Remontet L, Esteve J, Bouvier AM, et al. Cancer incidence and mortality in France over the period 1978–2000. Rev Epidemiol Sante Publique 2003;51: 3–30.
17. Harris LV, Kahwa IA. Asbestos: old foe in 21st century developing countries. Sci Total Environ 2003;307:1–3.
18. Spirtas R, Heineman EF, Bernstein L, et al. Malignant mesothelioma: attributable risk of asbestos exposure. Occup Environ Med 1994;51:804–11.
19. Roggli VL, Oury TD, Moffatt EJ. Malignant mesothelioma in women. Anat Pathol 1997;2:147–63.
20. Albin M, Magnani C, Krstev S, et al. Asbestos and cancer: an overview of current trends in Europe. Environ Health Perspect 1999;107(Suppl 2):289–98.
21. Schneider J, Woitowitz H-J. Asbestos-related non-occupational malignant mesothelioma. In: Peters GA, Peters BJ (eds) Sourcebook on asbestos diseases, vol 17. Charlottesville, VA: Lexis; 1998;43–69.
22. Hillerdal G. Mesothelioma: cases associated with non-occupational and low dose exposures. Occup Environ Med 1999;56:505–13.

23. Iwatsubo Y, Pairon JC, Boutin C, et al. Pleural mesothelioma: dose-response relation at low levels of asbestos exposure in a French population-based case-control study. Am J Epidemiol 1998;148:133–42.
24. De Klerk NH, Armstrong BK. The epidemiology of asbestos and mesothelioma. In: Henderson DW, Shilkin KB, Langlois SL, Whitaker D (eds) Malignant mesothelioma. New York: Hemisphere; 1992:223–50.
25. Berry G, Newhouse ML, Wagner JC. Mortality from all cancers of asbestos factory workers in east London 1933–80. Occup Environ Med 2000;57: 782–5.
26. Neumann V, Muller KM, Fischer M. Peritoneal mesothelioma—incidence and etiology. Pathologie 1999;20:169–76.
27. Roggli VL, Coin P. Mineralogy of asbestos. In: Roggli VL, Greenberg SD, Pratt PC (eds) Pathology of asbestos-associated diseases. Boston: Little, Brown; 1992:1–17.
28. Hodgson JT, Darnton A. The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure. Ann Occup Hyg 2000;44:565–601.
29. McDonald JC, McDonald AD. Chrysotile, tremolite and carcinogenicity. Ann Occup Hyg 1997;91:699–705.
30. McDonald, C. Asbestos in epidemiology of work related diseases, 2nd edition. London: BMJ Publishing Group; 2000:102–3.
31. Mossman BT, Gee JB. Asbestos-related cancer and the amphibole hypothesis. Am J Public Health 1997;87:689–90.
32. Cullen MR. Chrysotile asbestos: enough is enough. Lancet 1998;351:1377–8.
33. Stayner LT, Dankovic DA, Lemen RA. Occupational exposure to chrysotile asbestos and cancer risk: a review of the amphibole hypothesis. Am J Public Health 1996;86;179–86.
34. McDonald JC, McDonald AD. Asbestos and carcinogenicity. Science 1990; 249:844.
35. Stanton MF, Layard M, Tegeris, et al. Relation of particle dimension to carcinogenicity in amphibole asbestoses and other fibrous minerals. J Natl Cancer Inst 1981;67:965–75.
36. Wagner JC. Asbestos-related cancer and the amphibole hypothesis. Am J Public Health 1997;87:487–8.
37. Berman DW, Crump KS. Final draft: technical support document for a protocol to assess asbestos-related risk. Washington, DC: U.S. Environmental Protection Agency, 2004.
38. Churg A. Neoplastic asbestos-induced disease. In: Churg A, Green FHY (eds) Pathology of occupational lung disease, 2nd edition. Baltimore: Williams & Wilkins; 1998:339–91.
39. Roggli, VL, Brody, AR. Experimental models of asbestos-related diseases. In: Roggli VL, Greenberg SD, Pratt PC (eds) Pathology of asbestos-associated diseases. Boston: Little, Brown; 1992:257–97.
40. Report of the expert panel on health effects of asbestos and synthetic vitreous fibers: the influence of fiber length. Washington, DC: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, 2003.
41. Boutin C, Dumortier P, Rey F, et al. Black spots concentrate oncogenic asbestos fibers in the parietal pleura: thoracoscopic and mineralogic study. Am J Respir Crit Care Med 1996;153:444–9.

42. Ferguson DA, Berry G, Jelihovsky T, et al. The Australian mesothelioma surveillance program 1979–1985. Med J Aust 1987;147:166–72.
43. Lanphear BP, Buncher CR. Latent period for malignant mesothelioma of occupational origin. J Occup Med 1992;34:718–21.
44. Woitowitz H-J, Kraus T. Screening of asbestos-exposed workers in Germany. In: People and Work Research Reports, vol 36. Helsinki: Finnish Institute of Occupational Health; 2000:42–52.
45. McDonald JC, McDonald AD. Mesothelioma: is there a background? In: Jaurand M-C, Bignon J (eds) The mesothelial cell and mesothelioma. New York: Marcel Dekker; 1994:37–45.
46. Baris I, Simonato L, Artvinli M, et al. Epidemiological and environmental evidence of the health effects of exposure to erionite fibers: a four-year study in the Cappadocian region of Turkey. Int J Cancer 1987;39:10–17.
47. Baris YI, Simonato L, Saracci R, et al. The epidemic of respiratory cancer associated with erionite fibers in the Cappadocian region of Turkey. In: Elliott P, Cuzick J, English D, (eds) Geographical and environmental epidemiology: methods for small-area studies. Oxford: Oxford University Press; 1992: 310–22.
48. Metintas M, Hillerdal G, Metintas S. Malignant mesothelioma due to environmental exposure to erionite: follow-up of a Turkish emigrant cohort. Eur Respir J 1999;13:523–6.
49. Comin CE, de Klerk NH, Henderson DW. Malignant mesothelioma: current conundrums over risk estimates, and whither electron microscopy for diagnosis? Ultrastruct Pathol 1997;21:315–20.
50. Neugut AI, Ahsan H, Antman KH. Incidence of malignant pleural mesothelioma after thoracic radiotherapy. Cancer 1997;80:948–50.
51. Gold B, Kathren RL. Causes of death in a cohort of 260 plutonium workers. Health Phys 1998;75:236–40.
52. Cavazza LB, Travis WD, Travis JT III, et al. Post-irradiation malignant mesothelioma. Cancer 1996;77:1379–85.
53. Gentiloni N, Febbraro S, Barone C, et al. Peritoneal mesothelioma in recurrent familial peritonitis. J Clin Gastroenterol 1997;24:276–9.
54. Sakellariou K, Malamou-Mitsi V, Haritou A, et al. Malignant pleural mesothelioma from nonoccupational asbestos exposure in Metsovo (north-west Greece): slow end of an epidemic? Eur Respir J 1996;9:1206–10.
55. Constantopoulos SH, Sakellariou K. Non-occupational mesothelioma: epidemiological considerations. In: Peters GA, Peters BJ (eds) Sourcebook on asbestos diseases, vol 17. Charlottesville: VA: Lexis; 1998;17:71–97.
56. Henderson DW, Comin CE, Hammar SP, et al. Malignant mesothelioma of the pleura: current surgical pathology. In: Corrin B (ed) Pathology of lung tumors. New York: Churchill Livingstone; 1997:241–80.
57. Cicala C, Pompetti F, Carbone M. SV40 induces mesotheliomas in hamsters. Am J Pathol 1993;142:1524–33.
58. Statement on malignant mesothelioma in the United Kingdom: British Thoracic Society Standards of Care Committee. Thorax 2001;56:250–65.
59. Dawson A, Gibbs AR, Browne K, et al. Familial mesothelioma: details of 17 cases with hitopathologic findings and mineral analysis. Cancer 1992;70:1183–7.
60. Huncharek M: Non-asbestos related diffuse malignant mesothelioma. Tumori 2002;88:1–9.