Asbestos

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Abstract

Asbestos indicates a set of minerals of magnesium, calcium and iron silicate, ubiquitous in nature, having a typical microcrystalline fibrous structure. Asbestos fibers, when inhaled, can cause serious lung diseases; moreover, the fibers possess an extraordinary biopersistance and a high resistance to acids and alkalis, which allow it to remain in the pulmonary alveoli for a time almost indefinite. The diseases caused by asbestos can be distinguished in benign or malignant, but the most frequent are asbestosis, pleural mesothelioma and lung cancer. Asbestos is associated with occupational diseases and its presence is regulated by numerous laws. Occupational Physician must carry out health surveillance visits and examination in order to protect workers' health. Personal protective equipment used to protect the safety and health of workers exposed to asbestos are essential.

KEY WORDS: asbestos, health surveillance, occupational medicine, work, worker.

Introduction

Asbestos indicates a set of minerals of magnesium, calcium and iron silicate, ubiquitous in nature, having a typical microcrystalline fibrous structure that acquire once separated from the parent rock, as a result of enrichment and grinding phenomena. The term asbestos derives from the Latin *amiantus*, and from the Greek ἀμίαντος: unassailable, incorruptible (1).

Classification

From a mineralogical point of view, asbestos includes two large families, amphiboles and serpentines. The amphibole family consists of minerals composed of calcium and magnesium silicate, with a structure in brittle fibers, which can easily break. The amphiboles are divided into two groups: Monoclini and Ortorombici. Among the Monoclines are included:
1. *Actinolite*
2. *Amosite*
3. *Tremolite*
4. *Crocidolite.*

Actinolite occurs naturally in the form of fibers of variable length, up to 15 cm, which aggregate to form columns or fibrous radial structures, but can also be found in granular form. The name, attributed by Richard Kirwan, derives from the characteristic rounded shape that this subtype of asbestos, containing calcium, magnesium, iron and fluorine, most commonly assumes (from the Greek *aktinos*: radius, radiated stone) (2).

Amosite, also known as "brown asbestos", owes its name to the acronym AMOSA (Asbestos Mines of South Africa - asbestos mines in South Africa), referring to the main extraction site, that is South Africa. It has a structure very similar to that of actinolite, with long, thin and very fragile fibers. During the Twentieth century, it represented the most widespread sub-type

of asbestos, representing as much as 5% of all asbestos used in the construction of commercial buildings or factories (2).

The term *Tremolite* refers to a type of asbestos rich in magnesium and calcium, which owes its name to the location of discovery, Val Tremola in Switzerland. It appears as a mineral with variable shades, from colorless through gray to light green, in relation to the percentage of iron (0-20%) present in magnesium substitution (2).

Crocidolite (from the Greek κροκυς meaning "wool flake") is also known as blue asbestos or "Cape Asbestos" and is the most dangerous and toxic species. It has a fibrous and bluish colored appearance. In nature, it is found in the form of linear and flexible fibers, characterized by good resistance both to mechanical traction and to chemical acids. It constituted 3.5% of all world production.

The *Anthrophilite*, an amphibole rich in iron and magnesium, belongs to the group of Ortorombici, whose name derives from the Latin word anthophyllum: clove. Less than 1% of world production was represented by this subtype. In history the different types of amphibole asbestos have known different types of use, among which we remember:

- Insulator for the production of low density insulating panels and false ceiling panels
- Cement-asbestos for the production of slabs and pipes for construction, water pipes and for electrical and telecommunication services
- Thermal and chemical insulation (for example, fire doors, etc.)
- Production of filters for cigarettes in the 50s (only crocidolite) (2).

The serpentine asbestos family includes only Chrysotile, also known as "white asbestos" (from the Greek chfysos and tifos: gold fiber). It is a magnesium silicate with a typical curved appearance characterized by flat-structured fibers rotated around the central axis, forming tubular fibrillary subunits. In the twentieth century it had reached 3.5% of world production. The chrysotile fibers have an extremely variable length, being able to reach even 5 cm and a diameter between 0.7 and 1.5 µm, on the contrary the fibrillar subunits have a diameter of about 0.02 µm. In the past, chrysotile (sometimes even in the presence of amphibole contaminants) has been used in the automotive industry for the production of brake pads and clutch discs; in the mid-'90s, the old brake pads were replaced with new pads with ceramic, carbon, metal and aramid fiber coating (the same material used in bullet-proof vests). Chrysotile has also been used for the production of many different products and materials, including:

- Alkaline chloride membranes currently used in the USA
- Drywall, plaster and putty
- Filters for gas masks in the years prior to 1960
- Vinyl floors
- Tar for felts and coatings in general
- "Transite panels"
- Popcorn ceilings or acoustic ceilings
- Fire-retardant materials, fire-retardant clothing for firefighters
- Industrial gaskets
- Packaging materials
- Brakes, pads
- Fire blankets
- Internal fire doors
- Thermal insulation of the pipes
- Filters for the removal of fine dust from chemicals, liquids and wine (2).

History

The use of asbestos has very ancient roots in history: it has been used throughout history for many reasons, ranging from magical rituals to pharmacological preparations for the healing of scabies, varicose ulcers and leucorrhoea, up to the '60s when it was used in two types of preparations, such as a powder against sweating of the feet and a dental paste for fillings (3). Marco Polo himself wrote about a fiber cut into the rock, which was used in the fabrication of fire-resistant fabrics.

At the beginning of the industrial era and up to the '70s, there was a progressive increase in the use of this material, due to various reasons, including high availability in nature, low costs of extraction and processing.

Its properties of resistance to heat, steam, pressure and friction have made it an excellent material to be used in the production processes of all industrial sectors, especially in the automotive sector, such as in the manufacture of the braking devices of the cars.

Other uses include the use of asbestos in subways, ships and trains (for example in the construction of the Paris metro at the beginning of the 20th century and the transatlantic Queen Mary), in schools, in hospitals, in gyms and in cinemas, thanks to the exploitation of its thermal and acoustic insulation properties.

Numerous extraction plants were built in Canada, Russia, Italy, South Africa (4), Australia and Finland. Until 1990, it was possible to find the largest mine in western Europe and in Italy (the mine in Balangero, in Piedmont). There were also mines scattered throughout Italy, including Cavagnolo, Casale Monferrato, Reggio Emilia, Bagnoli and Syracuse.

In the '60s there was a peak in the use and production of cement-asbestos products for construction, the textile industry, chemistry, etc. Already at the end of the '60s the asbestos pathology became endemic in industrial areas and for this reason the use was limited to 1992, when Italy was the first European country to ban the use of asbestos (2); since 1994 all extraction, production or employment activities have been prohibited.

Asbestos fibers have properties, which, combined with

the already mentioned low cost of processing, have justified the extensive use that has occurred over the centuries in various industrial sectors, such as:

- Resistance to high temperatures and the action of chemicals that makes them virtually indestructible;
- Considerable flexibility
- Friability; sound absorption
- Thermal insulation.

Asbestos is dangerous for its inherent ability to release fibers that can be potentially inhalable and in the fact that they can break up into even smaller particles (2).

Pathology and symptoms

From a pathogenetic point of view, the fibers harmful to human health must meet specific criteria (5, 6): lengths exceeding 5 µm, diameter less than or equal to 3 µm and elongation ratio (length/diameter) greater than or equal to 3:1, criteria that trace the pathogenic characteristics of the fibers. In fact, a length of more than 5 µm is typical of biologically active fibers, as the fiber is too large to be completely swallowed by alveolar macrophages and then eliminated from the lung. The length/diameter ratio greater than or equal to 3:1 shows that the fiber can be easily inhaled and thus penetrate into the depths of the lungs. Even the diameter less than or equal to 3 µm suggests that the fiber is inhalable.

Fibers that meet these criteria are called regulated fibers; in terms of regulated fibers all the legal limit values are expressed.

Asbestos fibers, in turn, can separate along the length of their length, giving rise to "fibrils", ie thinner fibers, with a diameter of less than 3 µm.

The mere presence of asbestos does not imply a risk to human health.

The appearance of damage to human health is unequivocally linked to the presence of free and inhalable asbestos fibers in the environment. Exposure can occur essentially by ingestion or by inhalation, even if a very small amount of fibers can penetrate the body also by skin contact.

Following ingestion, the fibers are eliminated within a short time, usually a few days, via faecal excretion; cases have been reported in which some fibers have penetrated the cells of the gastro-intestinal system and others have reached the bloodstream.

A part of the fibers can be deposited inside the various tissues with which they come into contact, while others are eliminated by urinary tract.

In the literature there are many cases in which the intake of asbestos fibers, following the intake of contaminated drinking water, has led to health effects (7); the reasons are not yet known, although many subjects showed an increase in neoplastic diseases in the gastrointestinal apparatus, such as cancer of the esophagus, stomach and intestine, greater than the general population.

What implies greater dangers to the human species is, as mentioned above, the presence of airborne inhaled airborne fibers.

Asbestos fibers, when inhaled, can cause serious lung diseases; moreover, the fibers possess an extraordinary biopersistance and a high resistance to acids and alkalis, which allow it to remain in the pulmonary alveoli for a time almost indefinite (2, 5, 6).

At the pathophysiological level, the origin of the asbestosic lesion is triggered by an inflammatory reaction due to the macrophage attempts to eliminate the fibers, especially those with a length greater than 5 microns in the alveolar level and die (8).

The fibers, instead, which are less than 3 microns in diameter, penetrate the respiratory tract and remain in the lungs.

We need to make a clear distinction between the asbestos fibers belonging to the amphibole family and those belonging to the serpentine family due to the different basic structure and therefore to the different penetration capacity (9).

The amphiboles, as already mentioned, having a very straight fibrous structure, have a higher penetration capacity, which however decreases with increasing diameter, so this type of mineral presenting itself with a thin and needle-like appearance easily crosses the lung tissue and can reach the pleura also facilitated by respiratory movements.

The minerals that belong to the serpentine family, on the other hand, due to their curved shape, penetrate with greater difficulty into the pulmonary tissue and are more efficiently disposed of by muco-ciliary clearance.

We must not forget the possibility of finding fibers in the lymphatic ganglia, the spleen and other tissues, this happens above all for those that are able to be swallowed by bronchial and alveolar macrophages.

At the anatomopathological level it is not possible to distinguish between the various mineralogical families of asbestos.

The fibers which have come into the respiratory bronchioles and the pulmonary alveoli cause an inflammatory response and are phagocytized by the alveolar macrophages which are activated, producing in turn chemiotactic factors for the neutrophils; the latter would produce free radicals with a direct cytotoxic effect on the cells that line the alveoli, the type I pneumocytes, and with the stimulation effect of the proliferation and activation of fibroblasts of the interstitium. All this causes collagen deposition in the interstitium with thickening of the bronchial and alveolar wall and, in summary, leads to diffuse interstitial fibrosis (10, 11).

The presence of fibrous tissue modifies the characteristics of the pulmonary tissue making it less elastic and for this reason the parenchyma is stretched to each respiratory act leading to the formation of fibrous branches that surround large areas of air with the formation of real air cysts of varying sizes up to 5 mm in diameter.

At this point the lung assumes the characteristic "honeycomb" aspect of the asbestosic pathology that initially involves the lower lobes and the sub-pleural

zones and then the middle and upper lobes.
At the microscopic level, the typical "asbestos corpuscles" are typical, rods of brown-golden color up to 80 µm long, which can take on a "rosary beads" appearance, with swollen ends, which are formed by fibers of asbestos coated in layers by a protein substance and by ferritin. This aspect is given by the defense mechanism that the body implements to eliminate asbestos fibers through the attempts of phagocytosis by macrophages.
At the same time, the pleural plaques may also be present, thickenings of high collagen content and calcium of the parietal pleura, more frequently found on the diaphragmatic domes and on the anterior and posterior-lateral areas.
Asbestos pulmonary diseases occur long after the exposure begins, and in most cases they have a latency period of 20 years or more. The risk to health is directly linked to the quantity and type of fibers inhaled, to their chemical stability, and to a personal predisposition to develop the disease.
The diseases caused by asbestos can be distinguished in benign or malignant (10-12).
Among the benign, there are the so-called benign pleuropathies, which include three distinct clinical pictures, which do not constitute a real asbestos pathology and cannot be framed as asbestosis; moreover, there is not enough evidence that they go to malignant transformation; they are rather indicators of successful exposure to the mineral; they have rather a meaning of individual hypersensitivity to the sclerogenic action of asbestos.
Benign pleuropathies are generally asymptomatic and do not lead to changes in respiratory function unless they are very extensive following fibrotic phenomena of the lung parenchyma.
As already mentioned, benign pleuropathies can be divided into three distinct clinical pictures:
1. Pleural plaques
2. Diffuse pleural thickening
3. The benign pleural effusions (13).

The pleural plaques almost exclusively affect the parietal pleura including the diaphragmatic pleura sparing apices and braking costs; the plaques may have a variable extension and are generally referred to as circumscribed, multiple, often bilateral, sometimes symmetrical, fibrous thickenings and can go to calcification.
They represent a frequent finding in the exposed subjects, with a rather long latency period between the beginning of exposure and the appearance of plaques (10-30 years), and are due to the possible irritative action of the mineral on the pleura. They do not give symptoms and do not reduce respiratory function, unless they are numerous and/or large. Often they are discovered by chance, by performing a chest radiograph for other reasons; the appearance of plaques seems more related to the duration of exposure than to the dose.
The bilateral pleural plaques located at the parietal pleura constitute a fairly typical lesion from exposure to asbestos.
On the other hand, diffuse pleural thickening affects the visceral pleura and can also determine adhesions between the two pleural sheets. They can have both bilateral and monolateral localization and can calcify.
Unlike the pleural plaques located at the parietal pleura, the diffuse pleural thickenings represent a completely non-specific lesion, which also manifests itself as a consequence of common inflammatory processes.
The widespread pleural thickenings can be very extensive, even several centimeters, and cause alterations in the respiratory function.
Benign pleural effusions can generally appear in workers after at least 10 years of exposure, and are often the only manifestation in the lung parenchyma for another decade (10-12).
Normally they are modest and resolve spontaneously within a few months, but they can also recur years later. Frequently the diffuse pleural thickening and obliteration of the cost-frenic sinus result as a result.
They are not clinically distinguishable from the payments attributed to another cause and the differential diagnosis is essentially based on the lack of evidence of other causative factors (such as TB and tumors in particular) and on the anamnestic positivity for asbestos.
Another condition of the respiratory system induced by asbestos is represented by asbestosis, a chronic progressive respiratory disease, which may evolve into chronic respiratory failure due to the ability of asbestos fibers to induce pulmonary fibrosis resulting in stiffness and loss of function (13-16).
In asbestosis there is a close relationship between the inhaled asbestos dose and the body's response because the amount of asbestos that is trapped in the lungs is directly related to the total amount of inhaled asbestos, and therefore to the intensity and duration of the exposure; for this reason, asbestosis is considered a typical occupational exposure disease (17).
Symptoms of asbestosis are similar to those of other chronic respiratory diseases: dyspnea, stress first and then even at rest, cough, often dry, asthenia due to hypoxia (the amount of oxygen that passes from the alveoli to the blood is reduced).
Generally, asbestosis appears with a latency time of about 10 years from the first exposure and, in more or less long periods, leads to an aggravation of respiratory disorders, accompanied by an enlargement and a greater diffusion of radiological opacities, and by a progressive increase in functional deficit.
The phenomenon of "drum-drum" fingers can rarely appear and, in very advanced states, cyanosis. Over the years we can reach serious respiratory insufficiency pictures that can lead to exitus.
The disease can be complicated by the following clinical pictures:
- Infections from common germs
- Infections with tuberculosis germs
- Onset of lung tumors
- Onset of pleural mesotheliomas (13-16).

Cigarette smoking presents a synergistic action with asbestos, both being able to act unfavorably on the course of the disease, and to promote its evolutionary tendency (18-20).

To make a diagnosis of pulmonary asbestosis, a careful anamnesis is necessary above all, which must then subsequently be confirmed by diagnostic imaging tests.

Chest X-ray examination initially shows irregular opacities mostly in the lower pulmonary fields; subsequently there is a progressive involvement of the whole respiratory system and appears, in more advanced phases, the appearance defined as "frosted glass" and, therefore, radiological aspects "in nests of ape". Thickness and pleural calcifications, and obliteration of cost-frenic angles are often found.

The thickened interlobar septa give the CT images the appearance of linear intralobular opacities, lattice or lattice-nodular grid-like aspects. Subsequently, "frosted glass" and beehive-shaped lungs with cystic-looking air cavities can be observed.

Auscultation of the thorax may reveal pathological noises at the lung bases such as crackles and a harsh vesicular murmur.

The examinations of the respiratory function (spirometry) initially show a slight obstruction, therefore, afterwards a pronounced ventilatory deficit of a restrictive type with reduction of the alveolar-capillary diffusion (21).

Blood gas analysis can show arterial hypoxemia only in advanced stages.

The examination of the sputum can eventually bring to light the "corpuscles of asbestos", even if the lack of evidence does not allow to exclude the disease.

There is no specific therapy for asbestosis: the therapy is essentially aimed at hindering infectious complications and improving respiratory capacity.

The malign pathologies associated with exposure to asbestos are:

1. Pleural mesothelioma
2. Lung cancer
3. Tumors of the gastro-intestinal tract, larynx and other sites.

Pleural mesothelioma is an extremely severe malignant tumor that affects the serous membranes of lining the lungs. In addition, asbestos can also have a carcinogenic effect on the serous membranes of other districts of the organism (pericardial, peritoneal mesothelioma) (22-24).

The most affected age is between 40 and 60 years, with a greater predisposition of the male sex.

There is a long latency period between exposure to asbestos and the appearance of the neoplasm ranging from 15 to 45 years on average.

As far as pathogenesis is concerned, it has been observed that in reality asbestos is not a mutagenic agent per se; however, it is able to activate the proliferative RAS-MAP kinase pathway, thus favoring the self-phosphorylation of the EGFR. Furthermore, the crystalline forms containing also iron (crocidolite) are able to catalyze the synthesis of reactive oxygen species that are carcinogenic.

However, other etiopathogenetic factors influencing the development of neoplasia have been called into question, such as predisposing genetic alterations, chronic fibroplastic pleurisy, trauma, smoking, ionizing radiation and previous infections caused by SV40 virus (Simian virus 40). With regard to the latter, some studies have highlighted the presence of 2 antigens implicated in carcinogenesis: the nuclear antigen (small t antigen) that promotes the progression of the cell cycle by stimulating some kinases, and a larger antigen (the large t antigen) able to promote mutations and activation of the IGF-1 growth factor (22-24). Furthermore, both of these proteins seem capable of repressing several tumor suppressor genes. Some hypothesize that the two factors (exposure to asbestos fibers and viruses) act synergistically and that the asbestos fibers favor the carcinogenic action of the SV40.

Asbestos is still considered the main etiological agent of this neoplasm. However, there are no universally approved screening methodologies, at least in the exposed subjects known to be asbestos.

Several studies have been performed to detect the presence of serum exposure markers; among these there is mesothelin, a glycoprotein that has been increased in subjects exposed to asbestos which have subsequently been affected by mesothelioma. However, the increase of this marker is not related with certainty to the presence of the disease, so it is not predictive of disease (25-27).

There are also several cases of mesothelioma in people not exposed to asbestos who were living in areas with asbestos quarries, or in places with industries that worked such minerals and also the family members of those who worked in the sector. This data highlighted the potential danger of not particularly high concentrations of asbestos fibers (for example those present on the clothes of family members of workers in the sector): therefore, there is no threshold of safety below which the risk can be considered null.

As far as the anatomical and pathological aspects are concerned, mesothelioma is mainly localized in the basal and dorsal pleural segments, and presents macroscopically as a thickening of the pleura, typically widespread, associated with rigid and translucent whitish nodular formations with a wax stain" appearance (22-24); the thickening will eventually involve the whole pleura with incarceration of the lung, also accompanied by abundant hemorrhagic pleural effusion. In the initial phase, the tumor plaque is thin and circumscribed in its extension. In the advanced cases the nodularities are distributed over the entire thoracic surface, the mediastinum, the lung and the diaphragm (22-24).

There are three histological forms of pleural mesothelioma which are:

1. Epithelioid
2. Sarcomatoid
3. Biphasic.

The symptoms of mesothelioma are variable, that is, in relation to the moment in which diagnosis is made and to the eventual pulmonary involvement.

Initially, when the disease is localized to a single pleural cavity, it is asymptomatic for some months, while subsequently they arise:

- Dyspnoea (secondary to the pleural effusion serum-hemorrhagic and to the pleural thickening incarcerating the lung)
- Thoracic pain (dull and continuous, progressively more intense due to the progressive invasion of the chest wall)
- Irritating cough (due to airway involvement)
- Dysphonia (belatedly, by infiltration of laryngeal nerves)
- Mediastinal compression or infiltration syndromes persistent fever.

By progressing, the symptoms of neoplastic infiltration are worsened, up to cardio-respiratory failure, and the general conditions (cachexia) to the expiration progressively decline.

Metastatic repetitions by blood or lymphatics are also possible (22-24).

The prognosis is poor and survival is generally less than one year from diagnosis. To date, no effective therapies have been identified (5, 28).

The diagnosis is essentially radiological/histological, and obviously clinical.

The anamnesis can highlight occupational or environmental exposure to asbestos, while at the objective examination it is possible to detect the various objective signs related to pleural effusion such as:

- Pulmonary hypomobility
- Hypophonesis to percussion
- Reduction of the tactile vocal tremor at the palpation
- Reduction of vesicular murmur to auscultation.

The symptoms of pleural mesothelioma, which have been present for a long time and are very often underestimated, are:

- Chest pain
- Dyspnea
- Hemoptysis
- Cough
- Later
- Asthenia
- Anorexia
- Weight loss and low-grade fever appear later.

In all the suspected cases the investigation is deepened with other instrumental examinations, including chest radiography, CT and histological examinations on biopsy samples (22, 29, 30).

Chest X-ray examination can confirm the effusion and highlight the mammellonial appearance of the pleura. Chest CT allows to define the exact extension of the neoplastic process, to highlight the involvement of the lymph nodes of the mediastinum, the presence of pulmonary nodules and costal erosions. For diagnostic confirmation, pleural biopsy, transparietal or pleuroscopy is required, with histological examination supported by electron microscopy and immunohistochemistry for CEA and MPG 2 markers. Transparietal biopsy is useful only in case of positivity; otherwise, more invasive methods should be used. Pleural fluid needle aspiration and exfoliative cytology are not useful for diagnostic purposes due to the high frequency of false negatives and false positives. Thoracoscopy is the optimal investigation because it allows to explore the entire pleural cavity and to obtain large samples of tissue; if the pleural cord appears to be obliterated, it is necessary to resort to thoracotomy pleural biopsy.

As far as the blood tests are concerned, they are not usually used to arrive at a diagnosis, but they can be useful in follow-up, in particular the levels of osteopontin and serum mesothelin are higher in mesothelioma than in unaffected subjects. Also important are the tests of respiratory and cardiac function, and the EGA.

PET seems to be useful in the follow-up because the positivity of the lesions seems to be related to the effectiveness of the therapies performed.

As already mentioned the course of mesotheliomas is almost always very rapid, and accompanied by a progressive deterioration of the general conditions that leads to exitus. Moreover, the tumor easily gives both blood and lymphatic metastases with possible spread of the tumor to other sites of the organism.

Survival is typically less than one year from diagnosis and, especially in young subjects, can be limited to only six months.

To date, no effective therapies have been identified.

Evolution depends above all on the histological picture, in fact it is very rapidly progressive in the sarcomatous forms while it is slower in the epithelial forms; in any case, the treatment options are as follows: surgery (mainly palliative), radiotherapy, neoadjuvant/adjuvant chemotherapy, endocavitary immunotherapy, endocavitary chemotherapy, endocavitary photodynamic therapy, pleural talcage, simple drainage.

The so-called trimodal therapy is potentially indicated in highly selected patients in the initial stages (3-4 cycles of neoadjuvant chemotherapy: cis-platinum + pemetrexed – enlarged extrapleural Pleuropneumonectomy – targeted radiotherapy). It offered the best prognosis by allowing survival periods of more than 30 months to be achieved. Pulmonary carcinoma is generally the most frequent malignancy.

Asbestos can have a carcinogenic effect on the lung and its effects are enhanced by the action of cigarette smoke, since a close relationship has been found between the total amount of inhaled asbestos fibers and the habit of smoking. Epidemiological studies have shown an increased risk of developing lung cancer on the basis of asbestos exposure associated with or not smoking, especially when compared to non-smokers not exposed to asbestos, the risk is 5 times higher in non-smokers exposed to asbestos, 10 times higher in non-exposed smokers and even over 50 times higher in smokers exposed to asbestos (18-20).

As regards mineralogy, the various asbestos families present a different hazard; in the lung tumor the amphiboles of the serpentini are more dangerous, the long fibers, greater than 5 micrometres, compared to the short ones that are instead associated with the mesothelioma.

In addition, lung cancer occurs more frequently in

people already suffering from asbestosis (13-15).
Like mesothelioma, lung cancer also usually appears many years after the beginning of exposure and may also occur due to low levels of asbestos exposure; unlike mesothelioma, lung cancer is also frequently linked to other causes; however, the etiologically referable type to asbestos exposure is not clinically different from a cancer without any relation to this exposure: clinical picture, diagnosis, prognosis and therapy are unchanged (5, 6, 31, 32).
Adenocarcinoma would be more common in workers exposed to asbestos. Various studies have shown an exposure/effect relationship, perhaps of a linear type. It seems that the exposure resulting from the manufacture of insulating material and products, especially textiles based on asbestos, increases the risk compared to that observed in exposure from operations of extraction and shredding of chrysotile.
Lung cancer is a subtle disease that in many cases does not show signs of itself until it reaches an advanced stage.
Symptoms can be very different and mostly consist of:

- Chronic productive cough
- Breathlessness
- Chest pain
- Hemoptysis.

Other symptoms associated with these symptoms include: fever, asthenia, weight loss, pain in the shoulder or upper limb, slow-resolution pneumonia or recurrent pneumonia, dysphonia, dysphagia, bone pain, neurological symptoms, metabolic and neuromuscular (possible expression of repetitions remote metastatic and/or paraneoplastic syndromes), serious impairment of general conditions.
The diagnosis is mainly radiographic and can be completed by the microscopic examination of the sputum and other instrumental investigations.
The history can lead to suspect the presence of a neoplasm and can provide early information indicating the possible localization.
The physical examination is usually nonspecific: however, occasionally metastatic signs (enlarged lymph nodes or hepatomegaly) can be detected.
The chest X-ray shows the lesion, its position and its anatomical relationships with the surrounding structures, and is related to the affected site: in asymptomatic patients, it generally shows a peripheral nodular mass. Instead, in symptomatic patients, it may show bronchial narrowings and irregularities, parenchymal infiltrations or atelectasis. Pleural effusions are often associated with infiltrating or peripheral neoplasms; cytologic examination of pleural fluid or pleural biopsy may allow diagnosis.
The chest CT scan may show calcifications and small lesions not detectable with other procedures; it is also useful in staging, as it can detect the presence of hepatic, cerebral and adrenal metastases.
The chest MRI is only necessary in the visualization of the thoracic wall and of the involvement of the vertebral body in the Pancoast tumors of the apex.
Scintigraphy may indicate skeletal involvement due to metastasis.
Bronchoscopy is used to visualize and submit bronchial tumors to biopsy. Sometimes it is necessary to perform an exploratory thoracotomy to establish the diagnosis and resectability of cancer.
Sputum cytology and tissue biopsy can directly determine the presence of primary tumors and metastases.
All the above checks, together with others such as tests of respiratory function, allow to understand if the disease can be removed surgically.
In the initial stages of the disease surgery is the main therapeutic weapon associated with the best results in terms of healing. Generally, it consists in the removal of the portion of the diseased lung and of the nearby lymph nodes (ilo-mediastinal lymphadenectomy). Even in the presence of single metastases, surgery can have a curative role and in patients where the disease has been found in an advanced stage, even in association with radiotherapy, it can play a palliative role.
When the disease cannot take a surgical approach, oncological medical therapies and radiotherapy may represent various treatment options: radiotherapy can be used alone or in with chemotherapy and/or surgery to treat all types of lung carcinoma.
The choice of the best therapeutic approach is based above all on the extension of the tumor: in cases of localized chest disease, but with involvement of the mediastinal lymph nodes or other thoracic organs (for example, large vessels), a combined approach of chemotherapy is suggested, radiotherapy and, in selected cases, of surgery; in cases of “extra-thoracic” disease, pharmacological therapy is generally used, represented by chemotherapy and/or so-called biological therapies.
Despite the progress in the diagnostic-therapeutic field that make it possible to make the treatment more personalized and patient-oriented and basic neoplasia, lung cancer leads to a progressive deterioration of the patient’s health condition.
Exposure to asbestos was also associated with the possibility of developing tumors at the level of the gastrointestinal and larynx for which a frequency of occurrence was reported, however, much lower than that reported for lung tumors.
From a clinical point of view, these tumors are similar to the tumors of these same districts but due to other etiology; impairment of the general state of health, signs and symptoms from functional changes of the affected organs, signs and symptoms of compression of the adjacent organs and disorders related to metastatic localizations are recalled.
At present time, studies are under way to better define the mechanisms underlying the exposure/effect relationship, not yet fully defined and with the possibility that other factors may intervene.

Normative requirements

In the updated list of occupational diseases (Ministerial Decree June 10th 2014) (17), asbestos is associated with:

- Pulmonary asbestosis, plaques and/or pleural thickening (list I, group 4 - respiratory diseases not included in other items excluding tumors as reported in group 6)
- Pleural mesothelioma, pericardial mesothelioma, peritoneal mesothelioma, vaginal tunic mesothelioma of the testis, lung tumors (list I, group 6 - occupational tumors)
- Laryngeal tumors (list II, group 6 - occupational tumors)
- Gastrointestinal tumors (list III, group 6 - occupational tumors), where the list I indicates the "Diseases whose work origin is highly probable", the list II the "Diseases whose work origin is of limited probability" and the list III the "Diseases whose work origin is possible".

Justified by the aforementioned asbestos toxicity, the Italian state from 1992 to today has dictated a series of laws and ministerial decrees on health protection regarding asbestos.

Schematically, in chronological order, the following measures have been adopted:

- Law No. 257 of March 27th, 1992
- Ministerial Decree No. 288 of September 6th, 1994
- Ministerial Decree No. 251 of May 14tth, 1996
- Ministerial Decree No. 249 of August 20th, 1999
- Ministerial Decree No. 101 of March 18th, 2003
- Ministerial Decree No. 248 of July 29th, 2004
- Ministerial Decree No. 31 of December 14th, 2004
- Law No. 62 of April 18th, 2005
- Legislative Decree No. 257 of July 25th, 2006
- Legislative Decree No. 81 of April 09th, 2008
- Law No. 10 of April 29th, 2014.

As previously mentioned, Italy was the first state in Europe to ban the use of asbestos, with the law No. 257 of 27th March 1992 (33). On the one hand, through this law, the Italian State established the cessation of all activities involving the extraction, production and trade of asbestos, and on the other hand there was no absolute prohibition on the use of materials containing asbestos purchased before 1994. It also states that "the cost of removal operations is borne by the owners of the buildings".

It is necessary to wait two years to have indications regarding the regulations and the methodologies for the risk assessment, the reclamation, the control and the maintenance of the materials containing asbestos present in the buildings, established with the Decree of the Ministry of Health No. 288 of September 6th, 1994 (34).

With Ministerial Decree No. 251 of May 14th, 1996 (35), the regulations and technical methods for the reclamation of prefabricated units, pipes and cement-asbestos containers, including those to make asbestos harmless, are established.

In 1999, the Ministry of Health, the Ministry of Industry, Commerce and Craftsmanship, through the enactment of Decree No. 249 of August 20th, 1999 (36), dictate the regulations and technical methods for the remediation of materials with asbestos on board ships. The aforementioned decree is divided into 3 annexes:

- In Annex 1 the "rules and technical methods for the removal of materials containing asbestos present on board ships or similar units" are indicated
- Annex 2 regulates "the minimum performance requirements of the encapsulating coatings, the application protocols and the obligations that are required to correctly perform the remediation of asbestos cement products in compliance with the provisions of art. 3 of the Ministerial Decree of 6 September 1994"
- In Annex 3 the "criteria for the selection of personal protective equipment for the respiratory tract" are dictated.

This decree applies in the case of interventions on materials containing asbestos on board ships with Italian flag, as well as those with foreign flag that perform the aforementioned interventions at Italian ports or in shipyards in Italian territory.

Ministerial Decree No.101 of March 18th 2003 (37) of the Ministry of the Environment and Territory Protection, in agreement with the Minister of Economy and Finance, issues the Regulations for the mapping of the areas of the national territory affected by the presence of asbestos, pursuant to Article 20 of the Law of 23rd March 2001, No. 93. According to which it is disposed that:

- Art.1: regulation for the mapping of the areas of the national territory affected by the presence of asbestos
- Art.2: Criteria for the mapping and for the identification of urgent interventions
- Art.3: Tools for the realization of the mapping
- Art.4: Reclamation interventions
- Art.5: Financial coverage.

Regarding the criteria for the mapping of the presence of asbestos, two questions must be taken into account:

A) RESEARCH CATEGORIES:

- Category I - ACTIVE OR DISPOSED INDUSTRIAL PLANTS
- Category 2- PUBLIC AND PRIVATE BUILDINGS such as "schools of all levels, hospitals and nursing homes, public administration offices, sports facilities, large commercial distribution, prisons, cinemas, theaters, meeting rooms, libraries, places of worship, buildings buildings, farm buildings and their appurtenances, industrial buildings and their appurtenances".
- Category 3- NATURE PRESENCE which provides "in addition to the mapping of rock masses characterized by the presence of asbestos" should be highlighted both "mining activities, in cultivation or abandoned processing of rocks and minerals with the presence of asbestos" and "without the presence of asbestos in areas suspected of asbestos".
- Category 4- ANOTHER PRESENCE OF ASBESTOS FROM ANTI-PEOPLE ACTIVITY that means "homogeneous territorial areas with a high diffusion of the use of materials containing as-

bestos", referring to the quantity of materials containing asbestos deriving from the Asbestos Census.

B) FUNDAMENTAL DATA FOR THE SITES MAPPING:

- Complete localization of the site
- Site extension
- Persistence of activity - if affirmative sector and type of production
- Date of disposal or abandonment of the existing structures
- Conservation status
- Accessibility
- Distance from the inhabited center
- Density of the population concerned
- Type of asbestos present (type of mineral)
- Type of material (friable and/or compact)
- Estimated amount of material
- Performing remediation (excluding removal)
- Surface exposed to air
- Presence of airborne fibers
- Involvement of the site in urban works
- Presence of a maintenance and control program
- Epidemiological data (asbestos-related diseases in the territory)
- Presence of causes that create or favor the dispersion of fibers.

Ministerial Decree no. 248 of 29 th July 2004 (38) dictates the Regulation concerning the determination and discipline of recovery activities for asbestos-containing and asbestos products and goods. This decree dictates "the technical regulations on how to transport and store asbestos waste as well as the treatment, packaging and covering of the waste in landfills".

"The technical specifications define and identify the waste treatment processes containing asbestos. The treatments that, as an effect, lead to the total crystallochemical transformation of asbestos, make it possible to reuse this material as raw material".

- Annex A defines: management of waste containing asbestos Destination of waste containing asbestos Covering of waste containing asbestos Treatment of waste containing asbestos.
- Annex 1: indicates the determination of the release index for asbestos-containing waste. "To determine the release index for the purpose of identifying the destination of the waste containing asbestos, it is necessary to know the percentage of asbestos by weight present in the sample and the value of its absolute density".
- Annex 2: indicates the methodologies for the control of materials obtained by RCA treatments that do not modify the crystallochemical structure of the asbestos.
- Annex 3: indicates the methodologies for the control of materials obtained by RCA treatments that modify the crystallochemical structure of asbestos.

Ministerial Decree No. 31 of December 14 th, 2004 (39), Ministry of Health: Prohibition of the installation of materials containing intentionally added asbestos.

The decree of the Ministry of Health of 14 th December 2004, although extremely late compared to the existing national legislation in the sector, represents a further small step forward in the limitation of use of materials containing asbestos (MCA) which constitute a source of danger for the human health and environmental contamination.

In fact, although the law n. 257/1992 had established the prohibition of "extraction, import, export, marketing and production of asbestos, asbestos products or products containing asbestos", it was still possible, prior to the entry into force of the D.M. December 14th, 2004, the use of these materials, provided they have previously been produced and/or purchased, by both public and private entities in possession of stored MCA.

With the law No. 62 of 18 th April 2005 (40) - "Provisions for the fulfillment of obligations deriving from Italy's membership of the European Communities. Community Law 2004 ", the Italian Government" is delegated to adopt, within eighteen months from the entry into force of this law, the legislative decrees containing the standards necessary to implement the directives included in the lists set out in Annexes A and B ". In Annex B of the aforementioned law, among the community directives, there is also that concerning asbestos, or the directive "2003/18/EEC of the European Parliament and of the Council, of 27th March 2003, amending Directive 83/477/EEC on the protection of workers from the risks related to exposure to asbestos at work".

With the Legislative Decree No. 257 of 25 th July 2006 (41) "Implementation of Directive 2003/18/EC on the protection of workers from risks arising from exposure to asbestos at work" the Italian State has implemented the European directive.

With the Legislative Decree n. 81 of 9 th April 2008 (42) "Consolidated text on health and safety at work", under Title IX Hazardous substances - Chapter III Protection from risks related to exposure to asbestos, the related implementing rules were issued to protect against risks associated with exposure to asbestos in the workplace, together with the Resolution of the Regional Council (RRC) No. 265 of 15th March 2011, called the "regional interpretative lines for the surveillance of work activities with exposure to asbestos (TITLE IX CHAPTER III Legislative Decree 81/08)". These two decrees currently represent the relevant legislation regarding the protection of health and safety in the workplace in relation to asbestos. Specifically, in the Legislative Decree 81/08 the first article concerning the field of application for the protection of workers exposed to asbestos (article 246) specifies that, "without prejudice to the provisions of law 27th March 1992, No. 257 (the first law in which the Italian state prohibited the activities of extraction, production and trade of asbestos) the rules of this decree apply to the remaining work activities that may involve, for workers, the risk of exposure to asbestos, such as maintenance, removal of asbestos or materials containing asbestos, disposal and treatment of related waste, as well as reclamation of the affected areas".

Article 247 further defines what are the fibrous silicates that are referred to as the asbestos:

a) Asbestos actinolite, No. CAS 77536-66-4
b) Asbestos grunerite (amosite), No. CAS 12172-73-5
c) Asbestos antimillitis, No. CAS 77536-67-5
d) Chrysotile, No. CAS 12001-29-5
e) Crocidolite, No. CAS 12001-28-4
f) Asbestos tremolite, No. CAS 77536-68-6.

The Employer (article 248) in activities in which there is the presence of materials containing asbestos even if there is the slightest doubt of the presence of this mineral, "before undertaking demolition or maintenance work, also asking for information to the owners of the premises, adopts all necessary measures aimed at identifying the presence of materials with potential asbestos content" in order to subsequently define the actions to be taken to protect the health and safety of workers and the general population.

A very important fact is that the identification of the presence of asbestos or the suspicion of the presence of material containing asbestos (article 248) is therefore a preliminary action to assess the risk.

In the risk assessment (article 249), "the employer assesses the risks due to asbestos dust and materials containing asbestos, in order to establish the nature and degree of exposure and preventive and protective measures from implement" which:

a) Notification to the Supervisory Board (article 250)
b) Adoption of prevention and protection measures (article 251) and hygiene measures (article 252)
c) Exposure control (Article 253)
d) Preventive planning of the measures necessary to ensure the safety and health of workers and the protection of the external environment in the demolition or removal of asbestos (article 256)
e) Information (article 257) and training (article 258) of workers
f) Health surveillance (article 259)
g) Registration of the exhibition (article 260).

The Employer and, subsequently, the Occupational Physician, can be faced with 4 types of work activities:

1. "Work activities with sporadic and low intensity exposures"
2. "Work activities with risk of exposure to asbestos, excluding removal and demolition with notification obligation (article 250)"
3. "Work activities of demolition or removal of asbestos with obligation to present the work plan"
4. "Work activities of demolition or removal of asbestos, with obligation to submit the work plan (article 256), in cases of urgency".

In cases where the risk assessment results in "sporadic and low intensity" exposure and that "the limit value of asbestos exposure is not exceeded in the working environment", article 250 does not apply (notification), 251 (adoption of prevention and protection measures), 259 (health surveillance) and 260 (exposure registration), in the following activities:

a) "brief non-continuous maintenance activities during which the work is carried out only on non-friable materials"
b) "removal without deterioration of non-degraded materials in which the asbestos fibers are firmly bound to a matrix"
c) "encapsulation and confinement of materials containing asbestos that are in good condition"
d) "air monitoring and control and sampling for the detection of the presence of asbestos in a given material".

The Permanent Consultative Commission has drawn up a list of SLIE activities (sporadic and low intensity exposures) modifying article 249 and integrating the Legislative Decree 3rd August 2009, n. 106 (43) "establishing that their occupational risk must be of the same order of magnitude as that indicated for the general population".

"SLIE activities are identified as activities performed for a maximum of 60 hours per year, for no more than 4 hours per single intervention and for no more than two interventions per month, and which correspond to a maximum level of exposure to asbestos of 10 ff/l calculated over an eight-hour reference period. The duration of the intervention is inclusive of time for site cleaning, safety of waste and decontamination of the operator. More than 3 employees must not be directly involved in the intervention and, where this is not possible, the number of workers exposed during the operation must be limited to the lowest possible number". Furthermore, no more than three workers must be assigned to each operation at the same time. The Permanent Consultative Commission has distinguished four working categories which, on the basis of current knowledge, can be part of the SLIE activities:

1. short non-continuous maintenance activities during which the work is carried out only on non-friable materials such as:
    - "maintenance interventions concerning the fixing of slabs in compact materials containing asbestos (MCA) in good state of conservation without traumatic intervention on them"
    - "repair of a reduced area (maximum of 10 m2) of asbestos-vinyl sheets or tiles by applying adhesives, impregnating agents, sealants or with limited coatings of covering sheaths, or similar products"
    - "application of inertizing products in plant elements containing non-friable MCA in good condition (e.g. pipe coatings)"
    - "non-traumatic displacement of undamaged compact MCA slabs abandoned on the ground, after encapsulating treatment"
    - "interventions resulting from the need to restore functionality, limited to small areas (maximum of 10 m^2), roofing or panels in non-friable MCA using slabs not containing asbestos; maintenance interventions to plant parts (with the exception of systems braking), equipment, machines, motors, etc., containing non-friable MCA, without direct action on MCA; activity of preservation of encapsulation with restoration of the coating; insertion, inside flues in non-friable MCA, of sections with a lower section

without wear or removal of material; Emergency interventions for breakage, on water pipes only aimed at restoring the flow and that do not require the use of cutting equipment with chip removal".

2. "Removal without deterioration of non-degraded materials in which the asbestos fibers are firmly bound to a matrix" such as: "removal of tanks and boxes for water, if these articles can be removed from their seat without having to resort to breakages of the same; Removal of a limited area (maximum of 10 m^2) of vinyl-asbestos tiles, slabs placed inside building or similar products in non-friable MCA, if these articles can be removed from their premises without having to resort to breakages of the same; Collection of small pieces (in amounts not exceeding the equivalent of 10 m^2) of non friable MCA, fallen and dispersed as a result of sudden and unforeseen events, after treatment with encapsulant".

3. "Encapsulation and confinement of materials containing asbestos in good condition" such as:
   - "interventions on non-friable MCA in good state of conservation aimed at the conservation of the product and/or of the material itself and implemented without preliminary treatment"
   - "securing of fragmented material (in a quantity not greater than the equivalent of 10 m^2), with laying of a plastic sheet (e.g. polyethylene) on the same and delimitation of the area, without any intervention or movement of the material itself".

4. "Surveillance and control of the air and sampling for the detection of the presence of asbestos in a given material".

Notwithstanding the foregoing, the SLIE activities must be guaranteed compliance with the hygiene rules (article 252) and the use of Personal Protective Equipment (PPE) of the respiratory tract, with an operational protection factor of not less than 30.
The employer is obliged to carry out the risk assessment "whenever changes occur that may result in a significant change in the exposure of workers to dust from asbestos or materials containing asbestos".
In the case of work activities with risk of exposure to asbestos, excluding removal and demolition, before the start of work, the employer is obliged to present "a notification to the competent Supervisory Board for the territory" (article 250); this notification must include a concise description of the following elements:
a) "Location of the building site"
b) "Types and quantities of asbestos handled"
c) "Activities and procedures applied"
d) "Number of workers concerned"
e) "Start date of work and its duration"
f) "Measures taken to limit the exposure of workers to asbestos".

By way of indication, the notification obligation can be identified among the following activities:
a) "Maintenance of plants, machines or appliances insulated with materials containing asbestos"
b) "Disposal and treatment of waste containing asbestos, as well as reclamation of the areas concerned"
c) "Operations for the simple collection and removal of materials containing asbestos in a compact matrix, for starting the landfill".

The case in which the employer needs to demolish or remove the asbestos is different: in this case, in addition to the obligation to notify, he also has the obligation to transmit the work plan to the Supervisory Board at least 30 days before the start of the works (article 256).
The work plan must not be confused with the operational safety plan, because the first one does not replace the second - except in cases where the work plan conforms to its own requirements and to those of the operational safety plan.
In the event that materials containing asbestos are to be demolished or removed, this work must be carried out by companies registered in the "National Register of Environmental Managers" (article 212 of Legislative Decree 152/06).
Registration in the National Register of Environmental Managers "must be renewed every five years, and constitutes a title for the exercise of waste collection, transport, trading and intermediation activities".
The plan includes the following measures to guarantee the protection of workers' health and safety and the protection of the external environment, in particular indications on:
a) "Removal of asbestos or asbestos-containing materials prior to the application of demolition techniques, unless such removal cannot pose a greater risk for workers than that represented by the fact that asbestos or asbestos-containing materials are left behind on site"
b) "Supply to workers of personal protective equipment: the PPE protection standard is set at 10 ff/liter (0.01 ff/cm^3), equal to one tenth of the limit value (art. 251 paragraph 1 letter b), without prejudice to the opportunity to maintain the 2 ff/liter protection target when it is possible"
c) "Verification of the absence of risks due to exposure to asbestos at the workplace, at the end of demolition or removal of asbestos"
d) "Adequate measures for the protection and decontamination of the personnel in charge of the works"
e) "Adequate measures for the protection of third parties and for the collection and disposal of materials"
f) "Adoption, if the limit values pursuant to art. 254 of the measures pursuant to art. 255, adapting them to the specific needs of the specific work"
g) "Nature of the works and their presumable duration"
h) "Place where the work will be carried out"

i) "Working techniques adopted for the removal of asbestos"
j) "Characteristics of the equipment or devices to be used to implement the provisions of letters d) and e)".

As already mentioned, it is important that the copy of the work plan be sent to the Supervisory Board, at least 30 days before the start of the work, because within this period the Supervisory Board may request additions to the work plan or even the modification, and do not release the operative prescription to the employer. Ultimately there is the possibility that the employer will find work that involves the demolition or removal of materials containing asbestos in urgency. In this case, the obligation to send the work plan with a 30-day notice is no longer required; however, it must contain, in addition to the date, also the time of the beginning of the works. Fall in urgent cases:

a) "Hygienic-sanitary risk situations such as to determine the need for prompt action"
b) "Situations in which the intervention is subject to significant organizational constraints, reasonably documented by the client, in particular to ensure continuity in the provision of essential services"
c) "The presence of damaged structures and materials for which the safety intervention is not deferrable, in order to avoid the dispersion of fibers"
d) "Interventions for occasional discovery of materials containing asbestos unrecognized during construction activities".

In addition, the employer must ensure that "workers or their representatives have access to the documentation" that is the subject of the notification, and whenever there are changes that may lead to an increase in exposure to asbestos dust.

The employer, before using the workers for activities that involve exposure to asbestos, has several obligations:

1. Informing workers
2. Train the workers
3. Perform health surveillance
4. Register the workers in the register of exhibitors.

The information (art. 257) of the workers consists in making them aware of:

a) Health risks due to exposure to dust or materials containing asbestos
b) Specific hygiene rules to be observed including the need not to smoke
c) The methods of cleaning and use of protective clothing and personal protective equipment
d) The special precautionary measures to be taken in minimizing exposure
e) "The existence of the limit value" (which is 0.1 fibers per cubic centimeter of air, measured as a weighted average over the reference time of eight hours) and the need for environmental monitoring.

By training we mean that "educational process through which to transfer to workers and other subjects of the system of prevention and business protection knowledge and procedures useful for the acquisition of skills for the safe conduct of their duties in the company and identification, reduction and risk management" (article 2, paragraph 1, letter aa) Legislative Decree 81/08). The training must be "sufficient and adequate, at regular intervals" and aimed at "all workers exposed or potentially exposed to powders containing asbestos" as established by art. 258.

"The content of training must be easily understandable to workers and must enable them to acquire the necessary knowledge and skills in the field of prevention and safety, in particular regarding":

a) "The properties of asbestos and its effects on health, including the synergistic effect of smoking"
b) "The types of products or materials that may contain asbestos"
c) "Operations that may result in asbestos exposure and the importance of prior checks to minimize such exposure"
d) "Safe working procedures, controls and protective equipment"
e) "The function, selection, selection, limits and correct use of respiratory protective devices"
f) "Emergency procedures"
g) "Decontamination procedures"
h) "Elimination of waste"
i) "The need for medical surveillance".

In addition, the decree states that: "Workers who have attended professional training courses can be involved in the removal, disposal of asbestos and the reclamation of the areas affected".

The training courses are differentiated according to the specific task in:

1. Asbestos removal, remediation and disposal workers with a minimum duration of 30 hours, consisting of 15 hours of basic module and 15 hours of address.
2. Personnel with management responsibilities with a minimum duration of 50 hours, including 15 hours of basic module and 35 hours of address.

The employer has the obligation to carry out health surveillance by entrusting it to the doctors responsible for workers professionally exposed to asbestos.

The organization that employs personnel exposed to asbestos has both management and financial charges related to health surveillance. Register workers in the register of exhibitors.

The employer who, despite the measures to limit the dispersion of fibers in the environment and the use of suitable PPE, in the exposure assessment, ascertains that the exposure has been higher than expected (i.e. one tenth of the limit value), and if the workers have found themselves in the conditions referred to in article 240 (unpredictable exposure), they register them in the register of the exhibits and send a copy to the Supervisory Board and to national institute for occupational accident insurance (NIOA).

The registration in the register must be understood as temporary, having to pursue the objective of non-permanent condition of exposure higher than indicated in article 251, paragraph 1, letter b).

The employer has the task of providing a copy of the documents to the Supervisory Board and the NIOA, also in the event of termination of the employment re-

lationship provides NIOA, through the Occupational Physician, the health and risk record of the worker concerned, together to the individual annotations contained in the register.
NIOA maintains the documents for forty years from the termination of exposure. This is because asbestos is a toxic that can damage the body even after several years from the end of exposure.
The registration of the worker in the register of the exhibits has both epidemiological and preventive purposes, however the fact of having been exhibited and being registered in the register does not constitute the condition or condition for claiming, in relation to the bodies in charge, the recognition of exposure asbestos for social security or insurance purposes. In order to be recognized as an asbestos pathology (NIOA pathology) it is necessary to present documentation certifying asbestos exposure and a statement indicating: types and quantities of asbestos-containing materials used and/or of the waste treated in case of disposal and reclamation activities, the activities carried out, the nature and duration of these activities, personal protection devices and other measures taken to protect the health of workers and the protection of surrounding environment, such as in particular localized, general suction systems, etc. any quantification of the exposures to which it is considered to have been submitted.
The documentation indicates that the worker has been exposed to asbestos, but this does not mean that he has developed a related disease.
The conditions that can facilitate the release of fibers by products in asbestos are:

- Handling/processing
- Vibrations
- Air currents
- Moisture infiltrations, etc.

Being able to increase the risk of release of such fibers, if the products that contain it are in poor condition or undergo various types of stress.
As already mentioned, asbestos toxicity is related to the ability to release inhalable free fibers into the environment. Therefore, to define the potential danger of asbestos, reference is made to the friability of the materials containing this substance; the Ministerial Decree September 6th, 1994 (Ministry of Health) has classified the materials containing asbestos in:
1. COMPACTS: “hard materials that can be crumbled or reduced to powder only with the use of mechanical tools (abrasive discs, drills, drills, etc.)”.
2. FRIABLE: “materials that can be easily crumbled or reduced to powder with the simple manual pressure”.
The materials containing friable asbestos are characterized by an easier detachment of fibers, because internally they are weakly cohesive with the rest of the material, while for the materials containing compact asbestos the release of potentially inhalable fibers is less frequent.

Based on the evaluation of the asbestos-containing material according to Ministerial Decree September 6th 1994, we can identify three different types of situations:

1. Integral materials not susceptible to damage.

These are situations in which there is no danger of release of current or potential asbestos fibers or of occupants' exposure, such as:

- Materials not accessible due to the presence of effective confinement
- Materials in good condition, not confined but in any case hardly accessible to the occupants
- Materials in good condition, accessible but difficult to damage due to the characteristics of the material (hard and compact)
- Non occupant exposure as asbestos is in unoccupied areas of the building.

2. Integral materials susceptible to damage.

These are situations in which there is a danger of potential release of asbestos fibers, such as:

- Materials in good condition that are easily damaged by the occupants
- Materials in good condition that are easily damaged during maintenance work
- Materials in good condition exposed to deterioration factors (vibrations, drafts, etc.).

In situations of this type, firstly, appropriate measures must be taken to avoid the risk of damage, and therefore implement a control and maintenance program. If the risk of damage can not be significantly reduced, a remediation action to be implemented in the medium term should be considered.

3. Damaged materials: these are situations in which there is a danger of release of asbestos fibers with possible exposure of occupants, such as:

- Visible or otherwise unconfined materials, in occupied areas of the building, which present themselves:
  - Damaged by occupants or by maintenance operations
  - Deteriorated due to external factors (vibrations, infiltrations of water, drafts, etc.), deteriorated by spontaneous degradation
  - Damaged or deteriorated materials or loose materials near ventilation systems.

These are the situations in which the need for a specific action to be implemented in a short time is determined, to eliminate the release of asbestos fibers into the environment.

Possible measures can be:

a. restoration of materials: asbestos is left in place without carrying out any proper remediation, but limiting itself to repairing the damaged areas and/or eliminating the potential causes of damage (modification of the ventilation system in the presence of air that erode the covering, repair of water leaks, elimination of sources of vibrations, interventions to avoid damage by occupants). It is applicable to materials in good condition that present

areas of damage that are not very large (less than 10% of the asbestos surface present in the area in question). It is the provision of election for covering pipes and boilers or for non-friable cement-type materials, which show limited damage. In the case of friable materials, it is applicable if the intact surface has sufficient cohesion not to cause a spontaneous release of fibers

b. remediation by removal, encapsulation or confinement of the asbestos.

The reclamation may concern the entire installation, or it may be limited to the areas of the building or to the areas of the installation where a release of fibers is determined. When there are situations of uncertain classification, an environmental investigation is also required to measure the concentration of airborne fibers.

Reclamation interventions can be implemented, both in the case of limited areas, for example limited to an environment or a building, and in the case of general interventions. They consist of:

1. Removal of asbestos materials
2. Encapsulation
3. Confinement.

- REMOVAL "is the most common procedure, because it eliminates any potential source of exposure and any need to implement specific precautions for the activities that take place in the building. It involves an extremely high risk for the workers involved and for the contamination of the environment; produces significant quantities of toxic and harmful waste that must be properly disposed of. It is the procedure that involves the highest costs and the longest execution times. It generally requires the application of a new material, replacing the removed asbestos".

- ENCAPSULATION "consists in the treatment of asbestos with penetrating or coating products that tend - depending on the type of product used - to incorporate the asbestos fibers, to restore adherence to the support, to form a protective film on the exposed surface. Costs and times of the intervention are more contained. It does not require the subsequent application of a substitute product and does not produce toxic waste. The risk for workers and for environmental pollution is generally lower than for removal. It is the treatment of choice for non-friable cement-like materials. The main drawback is the permanence in the building of the asbestos material and the consequent need to maintain a control and maintenance program. It is also necessary to periodically verify the effectiveness of the encapsulation which over time may alter or be damaged, and possibly repeat the treatment. The eventual removal of a previously encapsulated asbestos material is more complex, due to the difficulty in wetting the material due to the waterproofing effect of the treatment. Furthermore, encapsulation can alter the flame retardant and sound-absorbing properties of the asbestos coating".

- CONFINEMENT "consists of the installation of a sealed barrier that separates the asbestos from the occupied areas of the building. If it is not associated with an encapsulating treatment, the release of fibers continues within the confinement. Compared with encapsulation, it has the advantage of creating a shock-resistant barrier. It is indicated in the case of easily accessible materials, in particular for reclamation of circumscribed areas (e.g. a column). It is not indicated when it is necessary to frequently access the confined space. The cost is limited if the intervention does not involve moving the electrical, plumbing and heating systems, ventilation, etc. A control and maintenance program is always required as asbestos remains in the building; in addition, the barrier installed for confinement must be kept in good condition".

When you are in environments where there is asbestos, it is important to identify which type of intervention is more correct for the specific situation, having available a series of intervention strategies ranging from control to maintenance, up to the various methods of reclamation.

The indications for the choice of the reclamation method for orientation purposes can be:

- "Removal surgery is often not the best solution to reduce asbestos exposure. If it is improperly conducted, it can raise the concentration of airborne fibers, increasing, rather than reducing, the risk of asbestos-related diseases"
- "Accessible materials, especially if easily damaged, must be protected by suitable confinement
- Before choosing an encapsulation procedure, the suitability of the asbestos material to bear the weight of the encapsulation must be carefully evaluated"
- "All methods of remediation alternative to removal have lower costs in the short term"
- "Renovation or demolition of structures covered with asbestos must always be preceded by the removal of the asbestos itself".

In particular, encapsulation is not indicated:

- "In the case of very brittle materials or which have poor internal cohesion or adhesion to the substrate, as the encapsulant increases the structural weight, exacerbating the tendency of the material to delaminate or detach from the substrate"
- "In the case of friable materials of high thickness (greater than 2 cm), in which the treatment does not penetrate very deeply and therefore fails to return the adhesion to the underlying support".

On the other hand, weight gain can facilitate the detachment of asbestos:

- In case of water infiltration: the treatment waterproofs the material, so that water can be formed internally which weighs down the coating and dissolves the binders, determining detachment
- In the case of easily accessible materials, as the treatment forms a protective film that is poorly resistant to impact. It should never be carried out on surfaces that are not at least 3 meters in height, in areas subject to frequent maintenance or on surfaces, at any height, which may be damaged by tools (e.g. gyms' ceilings)

- In the case of installations subject to vibrations (airports, premises with heavy machinery, etc.): vibrations determine the release of fibers even if the material has been encapsulated.

As you can see, the best remediation intervention is the removal, even if this presents a high cost in the short term, but making a long-term comparison the cost increases due to the need for periodic checks and subsequent interventions to maintain the effectiveness and integrity of the treatment.

Restitution of the areas at the end of the reclamation works

According to the provisions of the Ministerial Decree 6th September 1994, (Regulations and technical methods for the application of article 6, paragraph 3, and of Article 12, paragraph 2, of Law 27 th March 1992, n.257, concerning the termination of the use of asbestos), it is up to the "officers of the competent Supervisory Board" to proceed to "certification of the return of environments reclaimed by asbestos", in order to "ensure that the areas concerned can be safely reoccupied", while "expenses related to the inspection inspection and the determination of the concentration of airborne fibers is to be charged to the customer for the reclamation work". The following must be verified: "absence of residues of materials containing asbestos within the reclaimed area; actual absence of asbestos fibers in the atmosphere included in the reclaimed area", through the use of a "procedure that involves the preliminary visual inspection and therefore the sampling of the air that must take place working in an appropriate way to disturb the surfaces in the area concerned (aggressive sampling)".

In addition to the above for the "general guide criteria", in this same DM, the "criteria for the certification of return" are also established, that is, once the premises have undergone reclamation work, they must be returned together with certifications certifying that:

(a) "assessments of the concentration of airborne asbestos fibers have been carried out in the reclaimed premises through the use of scanning electron microscopy"
b) "an average concentration of airborne fibers of not more than 2 ff/l is present in the premises themselves".

Article 5 paragraph 3 of Regional Law 29th April 2014 (44) "Regulations for the protection of health and territory from risks arising from asbestos" provides that all public and private entities owners of sites, buildings, plants, means of transport, artefacts and materials with the presence of asbestos are obliged, within 120 days from the date of publication of this law, have to notify the regional agency for environmental protection (REEP) territorially competent, indicating all the data related to the presence of asbestos. Pursuant to paragraph 4 of the same art. 5 are also obliged to the communication referred to in paragraph 3, within the same terms, all the entrepreneurial subjects who, according to current legislation, carry out asbestos removal and disposal activities. To this end, the "Self-certification cards" have been prepared, to be completed and sent to the competent Territorial Structures of REEP Sicily.

Control procedures for materials containing asbestos in place

In the Annex A RRC No. 265 of 15th March 2011 "Regional interpretative lines for monitoring work activities with exposure to asbestos (Title IX Chapter III Legislative Decree 81/08)" - Veneto Region, established that "the presence of materials containing asbestos in buildings or manufactures in general, implies for the owner the obligation to check the conditions of integrity of the materials themselves and to act accordingly for the reclamation in case of precariousness and hazard of the materials. To facilitate the objective assessment of the state of deterioration in the presence of asbestos cement roofing or other material containing asbestos in a compact matrix (pipes, chimney pipes, etc.), with reference to Ministerial Decree September 6th, 1994, also in order to define priorities for intervention and reclamation, it is advisable to resort to widespread evaluation procedures".

The methods of reclamation provided for by the regulations are therefore described, namely over-coverage, encapsulation and removal, bearing in mind that for small-scale reclamation works, an assessment should be carried out according to what is indicated for the SLIE activities:

"Over-coverage consists of a confinement operation that is achieved by installing a new roof over the asbestos-cement roof that is left in place when the structure is able to bear an additional permanent load; the encapsulation involves the use of products covering the asbestos-cement roof; prior to the application of these products it is necessary to treat the surface of the material in order to clean it and guarantee adhesion of the encapsulating product. The final treatment must be certified by the executing company. This intervention does not exempt the customer from the obligation to verify the state of conservation; the removal involves a total removal of asbestos and its possible replacement with other non-hazardous material (Annex A RRC No. 265 of March 15th, 2011 Regional interpretation guidelines for monitoring work with exposure to asbestos (Title IX chapter III D.Lgs. 81/08)"- Veneto Region).

The activities of the Supervisory Board are implemented both in the preventive phase and during construction and, as better specified in annex A RRC No. 265 of 15th March 2011 Regional interpretative lines for monitoring work activities with exposure to asbestos (Title IX Chapter III Legislative Decree 81/08) - Veneto Region, are aimed at:

1. "Evaluate the documentation presented at the time of the notifications and with the work plans verifying the suitability of the company, when foreseen, the completeness of the information presented, of the operating procedures and of the preventive measures foreseen in order to guarantee the

health and worker safety and environmental protection against pollution from dispersed air fibers.
2. Check during the construction, with on-site inspections, the adequacy and correct implementation of measures to protect the health and safety of workers and the protection of the external environment.
3. Verify that, at the end of the remediation intervention, the environmental conditions of return of the area exist in all cases where this is required by current legislation (areas destined to be reoccupied).

"In the case of dynamic confinement, the executing company will have to certify its tightness and efficiency. The company will be asked to communicate the date on which the leak tests are carried out to allow a possible verification".

Annex A RRC No. 265 of 15th March 2011 "Regional interpretative lines for monitoring work activities with exposure to asbestos (Title IX Chapter III Legislative Decree 81/08)" - Veneto Region, also specifies that "in relation to the extent of the risk, at the duration and complexity of the reclamation works Supervisory Board will carry out one or more inspections. In particular, they will occur:

- Personnel present on site: work shifts, health suitability, qualification for reclamation, training on protection from all risks present, identification card.
- Procedures for entry and exit of personnel from the confined area, if any, and decontamination of materials; verification of the depressors: positioning, operation, spare parts, generator set; work methods; correct use of PPE, training for use, conservation and maintenance; environmental measures carried out to monitor occupational exposure and environmental protection; accident prevention, in particular falling from above; microclimate; prevention of other possible risks; coordination of the client; compliance with the provisions of Title IV of Legislative Decree 81/08 (temporary and mobile construction sites).
- The Sample Environmental Monitoring Service may be performed to monitor worker exposure or pollution levels in the workplace at the most critical points or work stages.
- From the point of view of the potential risk of the different types of reclamation, the macro categories of the site are:

1. Sites that carry out static and dynamic confinement to contain powders, as in the case of reclamation on crumbling materials or rendered by removal techniques
2. Work sites that implement a static confinement containing powders
3. Sites that do not provide for confinement, as in the case of the removal of compact materials
4. Interventions on products containing asbestos with glove-bag techniques".

Health surveillance

In the case of workers professionally exposed to asbestos, the Occupational Physician must carry out the following health surveillance visits:

a) Preventive medical examination: to ascertain the absence of contraindications to the work to which the worker is destined for the purpose of assessing his suitability for the specific task
b) Periodic medical examination: to check the health status of workers and express the judgment of eligibility for the specific task. The frequency of such checks is usually established at least once a year. This frequency may take on a different frequency, established by the Occupational Physician according to the risk assessment. The Supervisory Board, with motivated provision, can dispose contents and frequency of health surveillance different from those indicated by the Occupational Physician
c) medical examination at the request of the worker, if it is deemed by the Occupational Physician to be related to the occupational risks or health conditions, likely to worsen due to the work carried out, in order to express the suitability for the specific task
d) Medical examination during the change of job in order to verify the eligibility for the specific task
e) Medical examination at the end of the employment relationship in the cases envisaged by current legislation

e-bis) pre-terminate medical examination

e-ter) medical examination before the resumption of work, following absence for reasons of health lasting more than sixty continuous days, in order to verify the eligibility for the task.

Subsequently, the Occupational Physician, based on the results of the medical examinations, can express one of the following judgments concerning the specific task:

a) Suitability
b) Partial, temporary or permanent suitability, with prescriptions or limitations
c) Temporary inability
d) Permanent inability.

Art. 259 of Legislative Decree 81/08 and subsequent amendments provides the following:

1. "Workers involved in the maintenance, removal of asbestos or materials containing asbestos, disposal and treatment of related waste, as well as cleaning up the affected areas referred to in Article 246, before being used to perform the aforementioned works and periodically, at least once every three years, or at regular intervals set by the Occupational Physician, they are subjected to a health check aimed at verifying the possibility of wearing respiratory protective equipment during work".
2. "Workers who have been registered only once in the register of exposed persons during their activity are subjected to a medical examination at the time of termination of the employment relationship; on this occasion the Occupational Physician must provide the worker with indications regarding the medical prescriptions to be observed and the op-

portunity to undergo subsequent medical checks". This article concerns workers exposed even "once" to levels above 1/10 of the exposure limit value.
The subsequent paragraphs of the art. 259 of Legislative Decree 81/08 establish:

3. "The health checks must include at least the individual anamnesis, the general clinical examination and in particular of the thorax, as well as examinations of the respiratory function".
4. "The Occupational Physician, on the basis of the evolution of scientific knowledge and the worker's health status, assesses the opportunity to perform other tests such as sputum cytology, chest radiography or tome densitometry".

For the evaluation of workers, non-invasive examinations are preferred and, only in cases where the Occupational Physician deems it necessary, more invasive tests may be used, although not in the first years of exposure. The above is in accordance with Italian legislation, according to which the use of radiological diagnostic tests must be "modulated according to the principles of justification and optimization", therefore the use of the aforesaid assessments is indicated when these are "sufficiently effective for potential diagnostic or therapeutic benefits". The health protocol to be implemented every year that should be carried out in a company that deals with asbestos reclamation is as follows:

- Medical examination
- Spirometry
- Research asbestos corpuscles in the sputum
- Cytology of the sputum
- Standard laboratory tests (blood count, creatinine, glycemia, transaminase, bilirubin and urinalysis).

Moreover, every three years it would be advisable to perform a chest X-ray, in three projections.
For the former exposed to asbestos, for which the objective of health surveillance is that of an early diagnosis of lung cancer, it is suggested to carry out the following protocol, every three years:

- Medical examination
- Spirometry
- Chest X-ray in three projections
- While laboratory tests (blood count, ESR, e.g. immunohistochemistry, mesothelin, osteopontin) are carried out annually.

In any case, given the known synergistic association between asbestos and cigarette smoke, it is advisable to sensitize the worker not to smoke or invite him to adhere to smoking cessation pathways.
If one of the following possibilities occurs, i.e. positive clinical objectivity, suspected RX or altered values of mesothelin or osteopontin, it is necessary to perform a low-dose spiral CT scan that can highlight malignant or benign alterations. The low dose spiral CT scan is an effective tool for early diagnosis, but we should not forget some limitations of this method such as the high number of false positives and the risk of overdiagnosis.
If the radiographic changes are of benign type, the protocol can be implemented with:

- Medical examination with spirometry
- Analysis of mesothelin and osteopontinina annually
- Three-year thoracic Rx.

If the radiographic alterations pose a suspicion of malignant neoplastic nature, the worker must be immediately sent by the oncologist specialist.

Personal protective equipment

Personal protective equipment (PPE) used to protect the safety and health of workers exposed to asbestos include:

1. Respiratory protective devices (such as a large face mask equipped with a filtration system);
2. Protective clothing:
   - Disposable coveralls with hood
   - Gloves
   - Overshoes
   - Safety footwear
   - Helmets.

Legislative decrees n. 475/1992 and n. 81/2008 (Title III - Chapter II) represent the part of national legislation that has implemented the European Directives concerning personal protective equipment (PPE).
Pursuant to Legislative Decree 475/1992, PPE placed on the market starting from 1st January 1995 must comply with the essential health and safety requirements, i.e. they must have the EC declaration of conformity, present the CE marking and the information note.

Protective clothing
Protective clothing must be chosen based on specific characteristics as indicated by the D.M. May 2nd 2001 of the Ministry of Labor which accepts the UNI 9609 standard.
In principle, the characteristics to be satisfied include:

- Total body coverage
- Use of air-tight or semi-permeable dustproof fabric
- Use of non-dust-retaining fabrics at pockets, seams, lacing.

In particular it is suggested to use:

- Whole suits (in cotton, tyvek, disposable gore-tex);
- Rubber boots (washable with high bootleg, non-slip sole, anti-puncture midsole, anti-crushing toe cap)
- Gloves.

Respiratory protection devices
The D.M. May 2nd 2001 of the Ministry of Labor also establishes the criteria for the selection of respiratory protective devices, in Annex 2 showing the standard UNI 10720 (1998).
The choice of devices for the protection of the respiratory tract to be used in case of exposure to harmful substances cannot be separated from a group of factors listed in the aforementioned Annex 2:

- "Risk assessment"
- "Extension and localization of risk"
- "Air purity"

- "Freedom of movement"
- "Field of view"
- "Oral communication"
- "Extreme climatic conditions"
- "Other PPE"
- "Extreme situations".

Naturally, in the choice of PPE the "degree of protection required in relation to the concentration of pollutants" must be carefully evaluated (Ministerial Decree 20/09/99), in this case represented by airborne asbestos fibers.

Annex 3 to the Ministerial Decree 20th August 1999 of the Ministry of Health, which replaced the Annex IV of the Ministerial Decree 6th September 1994, and to which reference should be made, shows the same criteria in the specific field of protection from asbestos fibers.

According to the Legislative Decree 81/08 article 251- Prevention and protection measures:

a) Exposed workers must always use personal protective equipment (PPE) of the respiratory tract with operational protection factor adequate to the concentration of asbestos in the air and such as to ensure the user in any case that the filtered air inside of the PPE is not more than one tenth of the limit value indicated in article 254
b) The use of PPE must be interspersed with rest periods appropriate to the physical effort required by the work, access to rest areas must be preceded by appropriate decontamination…

Regarding the PPE according to the art. 252 "Hygiene measures":

c) "Said working or protective clothing remains within the undertaking. They can be transported to the outside only for washing in laundries equipped for this type of operation, in closed containers, if the company itself does not provide it or in case of use of disposable garments for disposal according to the current provisions
d) Work or protective clothing must be kept in a separate place from that intended for civilian clothes;
e) Workers can have adequate sanitary facilities, equipped with showers, in case of operations in dusty environments
f) The protective equipment is stored in premises for this purpose intended and checked and cleaned after each use: measures are taken to repair or replace the defective or deteriorated equipment before each use".

Safety signs for asbestos

The current legislation refers to the safety signs to be placed in workplaces where asbestos is processed and in case the exposure limits set by the legislation are exceeded.

The following situations are reported:

I. In paragraph 4b of the Ministerial Decree September 6th 1994, it is reported that during maintenance work, in the case of significant releases of fibers, there must be defined procedures such as: evacuation and isolation of the affected area (closing of doors and/or installation of temporary barriers); posting notices of danger to prevent access by strangers; decontamination of the area by operators equipped with individual means of protection with wet systems and/or with suitable vacuums; final monitoring of verification.

II. In the Ministerial Decree September 6th 1994, in paragraph 4 letter a), Control program instead reports that the owner of the property and/or the person in charge of the activity must place "On installations subject to frequent maintenance interventions (e.g. boiler and pipes) be warned in order to prevent the asbestos from being inadvertently disturbed".

III. We suggest placing the safety signs on all places where asbestos is present.

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