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INTERNATIONAL BERYLLIUM RESEARCH CONFERENCE

Beryllium: What we know and what remains to be discovered

By Guy Perrault

Last March, the IRSST hosted the International Beryllium Research Conference, in partnership with the National Jewish Medical Research Center and the National Institute of Occupational Health and Safety. Some 250 people from 12 countries shared their knowledge...

Beryllium is a rare metal with unique properties. It has been harnessed by humans for use in its metal form or as an alloy with copper, aluminum or nickel. Three times lighter than aluminum, seven times more rigid than steel, beryllium (Be) augments the resistance of alloys to wear, fatigue and corrosion. Even though it was first used primarily for military purposes, it became evident that Be-containing dust particles could cause illnesses among workers. Control measures were then established.

Afterwards, a variety of commercial applications emerged. For example, springs or bolts made with Be alloys are more resistant. Pipes made with copper and beryllium alloys last longer than pipes made solely with copper. The mechanical components of fire sprinklers, air bag sensors and spark-resistant tools often contain Be. But have the same precautions taken during initial uses always been followed as new uses have emerged? Have they been sufficient? These are the questions that the recent conference in Montreal attempted to answer.

Background

The first manifestations of pulmonary diseases caused by the inhalation of Be-containing dust were described in the 1940s among workers in an industry using Be and in the neighbouring population. The disease, which developed rapidly after exposure, was called acute berylliosis. These observations led to the first recommendations on safe concentrations in workplaces (2 $\mu g/m^3$) and in the community (0.01 $\mu g/m^3$). In addition to pulmonary abnormalities, skin lesions were also reported.

The use of control methods to prevent these types of lesions had already been cited in documents from the 1950s to 1980 as a success story in the application of industrial hygiene principles to prevention.

Between 1980 and 1990, new knowledge shattered this assurance that the problem had been solved. At the time, scientists described cases that seemed to develop after several years of exposure. This marked the emergence of chronic berylliosis (CB). The immunologic nature of this disease was confirmed, with the explanation that the disease appeared mainly among patients who had developed hypersensitivity to Be. An accumulation of Be-specific cells was noted in bronchoalveolar lavages, leading to the development of a blood test, the Be lymphocyte proliferation test (BeLPT).

The development of this test was important for many reasons: confirmation of the sensitization step before the appearance of symptoms and the onset of chronic berylliosis; medical surveillance among sensitized workers, leading to rapid treatment upon the appearance of symptoms and, above all, identification of work stations and professions at risk, in order to prioritize prevention actions. The test also helped identify misdiagnosed cases that were often confused with sarcoidosis.

Diagnosis and treatment

The current criteria for diagnosing chronic berylliosis are evidence of sensitization by BeLPT tests in the blood or in bronchoalveolar lavages, accompanied by evidence of a pulmonary disease by biopsy, usually by the presence of granulomas. The number of positive tests and the use of other non-specific examinations such as degradation of pulmonary functions or pulmonary images taken by x-ray or axial tomodensitometry, which are characteristic of CB, vary from one organization or country to the next.

In the United States, 290 cases of chronic berylliosis have been reported since 1990, but all indications are that this number is underestimated. One study raises the possibility of 136,000 workers being exposed in the United States. Assuming that 5% of exposed workers may develop the disease, the number could rise to 6,500.

Following a CB-positive diagnosis, experts recommend termination of exposure. Even if there is no evidence that the disease is slowing down, case history seems to indicate that the situation tends to improve once exposure ceases. The use of corticosteroid therapy is recommended only upon the appearance of symptoms or the deterioration of respiratory functions. Progress in research on genetic sensitivity is improving our understanding of the mechanism involved in the development of the disease and could pave the way for new therapies.

Epidemiology

The results of epidemiologic studies over the past 15 years further capture the state of our knowledge of Be sensitization and the appearance of the disease. A dozen studies conducted on worker populations indicate prevalence ratios ranging from 0.8 to 11.8% with peaks of up to 20%. The other studies on the relationship between exposure and the risk of developing sensitization or CB show that medical surveillance backed by exposure measurements helps identify positions and situations of risk. Examples include brazing, welding, grinding, polishing and milling. Sensitization and CB developed among workers who were exposed to concentrations below the 2 $\mu g/m^3$ standard. Sensitization appeared among workers who were exposed to less than 0.1 $\mu g/m^3$. These studies suggest a few factors that may be important in the definition of risk, namely total exposure, characteristics of Be particles and the pathway into the organism, namely inhalation or skin penetration.

Prevention measures

As the development of CB attacks the immune system at extremely low doses and only a segment of the population of exposed workers reacts to Be, prevention of this disease requires the implementation of a rigorous program.

The engineering methods needed for such rigorous control include the complementary use of wet processing, ventilation and containment, in addition to administrative controls to limit exposure, such as limited access, promoting personal hygiene (two change rooms, skin protection, forbidding eating, smoking and drinking at the workplace), sampling surfaces to determine their cleanliness and, finally, informing and training workers.

Prevention model

The model for preventing diseases caused by Be is that of the U.S. Department of Energy, which includes the adoption of a proactive approach between managers and workers. The purpose of this model is to eliminate any dispersion or absorption of Be by guaranteeing clean work areas and procedures, keeping Be out of the lungs, avoiding deposition on the skin and clothing, removing dust at the source, preventing the transportation of Be outside the work area and the industrial site, and informing and training workers on prevention measures.

The preventive approach is based on several hypotheses that are still the subject of research around the world: Be sensitization can occur through skin absorption and inhalation. The development of CB requires persistent and long-term presence; biological availability in the understanding of sensitization and CB depends on the rate of absorption, the concentration and the physico-chemical properties of particles. The plausibility of sensitization by the skin has evolved following animal studies showing that particles of less than 1 µg can penetrate through the skin and possibly augment the proliferation of Be-activated blood lymphocytes.

Return to work?

Is it desirable, from a medical point of view, to remove sensitized people from their work? Current knowledge does not establish clearly whether termination of exposure delays the appearance of CB symptoms or slows down the progression of the disease.

What concentration is sufficiently low to protect workers suffering from beryllium sensitization or berylliosis and allow them to maintain their job? While there are no definitive answers to this question, there are some possible solutions. The concentration of Be in the air ranges from 0.00002 to 0.02 $\mu g/m^3$. In Pennsylvania, the average has been established at 0.0002 $\mu g/m^3$. The lowest concentrations associated with cases of CB in agglomerations close to industries using Be are around 0.01 $\mu g/m^3$. The Environmental Protection Agency (EPA) has adopted a standard of 0.01 $\mu g/m^3$ weighted on a monthly basis. In this case, the exposure is for 24 hours a day, 7 days a week, compared with 8 hours a day, 5 days a week at the workplace. The few studies that have reported data on the lowest concentrations associated with sensitization or Be at the workplace show figures ranging from 0.02 to 0.1 $\mu g/m^3$.

Based on these indications and on general knowledge of the problem, the best response suggests that a worker can only return to work if potential exposure is less than 0.01 $\mu g/m,^3$ on condition that the possibility of re-suspension of the Be dust is reduced to a minimum in work areas and that these requirements are based on certainty that Be has never been used in the work area where the worker is reassigned or that appropriate samples have been verified and continue to show that the concentration is less than 0.01 $\mu g/m^3$.

Medical surveillance

BeLPT remains the best tool for medical surveillance. It provides the most accurate prediction of the risk of CB, the possibility of an early diagnosis before the appearance of symptoms, the identification of risky operations and processes. However, the test suffers from the following limitations: the predictive values for individuals vary depending on the plant, the profession and the process; the inability to replicate the test may generate inconsistent immune response results; the absence of evidence to the effect that diagnosis changes the natural history of the disease.

New tests, complementary to BeLPT, are under development. These tests are derived from recent studies on genetic susceptibility and immunologic mechanisms, which suggest better or less invasive indicators than the blood test. However, these tests are not available presently for common usage.

Risk communication

In the United States, the task force on communication of the risks of Be has prepared a training manual for workers, supervisors and managers. This document is the product of a consensus between Be workers, workers suffering from berylliosis, industrial hygienists, occupational physicians, supervisors, union representatives, epidemiologists, toxicologists, psychologists, risk communication specialists and field instructors.

To find out more

- All the conferences presented at Be 2005 are available on IRSST Web site: http://www.irsst.qc.ca/en/intro-be-2005.html
- The Quebec CSST report on Be is available at the following address: http://www.csst.qc.ca/portail/fr/prevention/informations_supplementaires/beryllium/
- Chronic Beryllium Disease, Prevention Program, Final Rule, Department of Energy: http://www.eh.doe.gov/be/docs/berule.pdf
- Training Manual for Workers, Supervisors and Managers: http://www.eh.doe.gov/health/beryllium/communicating.pdf

Beryllium elsewhere

France

Two questionnaire surveys have been conducted in France to determine the use of Be in French industries, particularly in dental laboratories. The surveys show that about 12,000 workers could be exposed. Of this number, 14% are exposed at concentrations greater than 2 $\mu g/m^3$ and 43% above 0.2 $\mu g/m^3$. The percentage of dental laboratories that use Be-containing alloys declined from 50% to 14% from 1990 to 2003. A sample study of the breathing zone and verification of the contamination of surfaces in 100 French industries representing all users is ongoing to confirm the survey data.

Israel

In Israel, seven cases of berylliosis in dental laboratories and five cases in various metal industries were diagnosed in 2004. The use of Be in dental alloys has been banned.

India

No case of sensitization or berylliosis has been reported in an Indian Be extraction, powder production or machining plant. The engineering control measures and the use of personal protection measures are sophisticated and include an annual medical examination and screening using the BeLPT test. The arithmetic means of Be concentrations in the air went from 0.6 $\mu g/m^3$ in 1982 to less than 0.1 $\mu g/m^3$ in 1994.

Germany

Germany does not extract or produce Be. However, Be sensitization and berylliosis have been detected in the cohort of patients suffering from sarcoidosis. The cases of berylliosis cover a wide variety of industries and trades, particularly dental laboratories. Efforts to replace the BeLPT test with a simpler and more reliable test have not been successful.

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