EXPERIENCE IN THE UNITED STATES WITH PROPOSED SAFE LEVELS OF EXPOSURE TO TOXIC BERYLLIUM COMPOUNDS

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Utilizing my clinical experience with cases of beryllium disease, together with data accumulated in a registry of patients in the United States with beryllium poisoning, and the reports in the literature, I want to discuss the problem of beryllium poisoning and its control by keeping exposures at, or below, certain existing target levels.

In the United States, there are in current use three separate figures for the control of harmful effects of toxic beryllium compounds and, as far as I know, this is unique in industrial hygiene practice. These figures were proposed in 1948 by an advisory committee appointed by the Division of Biology and Medicine of the United States Atomic Energy Commission, of which I have been a member and all through its deliberations. The figures were recommendations intended for the prevention of beryllium disease at atomic energy laboratories only, but gradually they came into fairly wide usage. For a variety of reasons, in spite of impressive evidence of disability and death among certain groups of beryllium-exposed workers, there has been to date no definite action by industrial or government groups to adopt either the figures used by atomic energy projects or any other figures as maximum allowable concentration (M.A.C.) for toxic beryllium compounds.

In April 1958, the Beryllium Advisory Committee (as this group was named) voted to disband, hoping thereby to encourage policy-making industrial hygiene groups to adopt or modify these proposed safe levels for toxic beryllium exposure.

The Beryllium Advisory Committee had in its membership an industrial hygienist, a toxicologist, two physicians and, from time to time, consultants especially experienced with occupational disease were called on for advice. After initial deliberations, the Committee met annually to review new knowledge and to modify, if need be, the target levels for beryllium exposure tentatively suggested in 1948. At the insistence (wisely, I believe) of one member, it was agreed that the proposed safe beryllium levels should have the sanction of the Committee for only one year at a time. This was an attempt to keep the figures flexible so that if added data suggested that a change was necessary this could be achieved promptly. All of us interested in M.A.C.'s know how easily figures suggested in the literature as safe take on almost the force of law and rapidly become impossible to change.

I want to examine with you these three proposed levels of beryllium

exposure to see how valid they are in the light of almost a decade of experience, and whether we have sufficient grounds for suggesting their international adoption as M.A.C.'s.

The target level intended to prevent acute beryllium poisoning is 25 $\mu g/m^3$ of air for a short exposure. No time is given and I, together with other physicians, am not altogether satisfied with this aspect of the figure. I believe there is fairly universal agreement among United States industrial hygienists that 25 μg Be/m^3 of air is a safe level. The figure is based on actual experience with beryllium-caused illness at a level about, but not far above, 100 $\mu g/m^3$. In addition, Stockinger, Scott, and their associates at Rochester reported repeatable animal experiments producing beryllium-related changes at, and slightly below, the same figure (100 $\mu g/m^3$). As far as I know, and there has been a hard search for evidence to be certain, no illness has occurred in any worker exposed to toxic beryllium compounds at a concentration of 25 $\mu g/m^3$.

The figure used as the M.A.C. for a forty-hour week exposure is 2 $\mu g/m^3$ of air for an eight-hour day average. By stating the M.A.C. in this fashion it will be seen that the 25 $\mu g/m^3$ for short exposure is made more realistic. Neither limit shall be exceeded for the conditions stated. In current practice in the United States, those responsible for the control of exposure to toxic beryllium compounds, where possible, hold all exposures at, or below, the level of 2 $\mu g/m^3$ of air, regardless of the duration of the operation. Except for certain operations, especially in the extraction industry, correct industrial hygiene engineering seems to have made this possible.

The reasons for zeal in keeping steady beryllium exposure levels down are several. One is that disease still carries a fatality rate of 26 per cent. Another reason is that cases may appear ten years or even longer after the last exposure, suggesting that a small body burden of beryllium may be triggered into disease production as in carcinogenesis. Laboratory studies are in progress to test the suggestion of Sterner that hypersensitivity such as that encountered in the clinical behaviour of tuberculosis may be a factor in beryllium disease in some individuals. If hypersensitivity proves to be a factor in the development of clinically active beryllium poisoning, there is added reason for keeping beryllium exposure at a low level.

A decade after the proposal of the 2 $\mu g/m^3$ figure, it is of interest to note that, out of the 604 cases in the Beryllium Case Registry at the Massachusetts General Hospital, only 9 received their beryllium exposure after 1950. Thus, it appears to be true that the target levels proposed by the Beryllium Advisory Committee, even though not followed everywhere, resulted in a definite decrease in the number of cases. A great change in beryllium exposure to United States workers resulted from the decision of fluorescent lamp manufacturers, in May 1949, to discontinue the use of beryllium compounds in their phosphors. Since a few cases have occurred as long as 15 years after the last exposure to beryllium, more time must pass before it will be known with certainty whether the proposed figure of 2 $\mu g/m^3$ is entirely safe or whether it may prove conservative. The evidence suggests that the smaller the inhaled quantity of toxic beryllium compounds, the longer the delay between exposure and disease onset—a fact which will assist in judging M.A.C. Animal evidence is contributory in judging the existing figure of

2 $\mu g/m^3$ in that relatively low level exposures to various beryllium compounds have produced a variety of pathological changes. The literature is large on this subject and worth studying. For this discussion, it is adequate to point out that different workers have reported malignant change in bone and lung, and granulomatous change in lung and liver following various methods of administration of beryllium compounds. Other workers report no change whatsoever as a result of exposure of experimental animals to compounds of beryllium thought to be toxic. This experience highlights the difficulty of using experimental animal studies as a safe criterion for the establishment of M.A.C.'s.

Eisenbud of the New York Office of the Atomic Energy Commission and several members of the Beryllium Advisory Committee proposed the figure of 0·01 $\mu g/m^3$ of air for a weighted monthly average as the safe level of exposure to toxic beryllium compounds of people living near a beryllium-using plant. Experience in three states with fifty-odd cases of neighbourhood beryllium disease confirms the reality of such a hazard. It is possible that a number of clinically mild cases of beryllium poisoning have escaped detection in studies of communities near beryllium plants. The fact is that there are only 44 well-documented cases of individuals who suffered chronic beryllium intoxication without ever going into a beryllium plant. This group has the high mortality rate of 54 per cent.

The figure Eisenbud proposed took into consideration a 24-hour daily exposure, if a hazard existed, and exposure to children. There has been considerable discussion among those interested as to the wisdom of having such very different safe level figures for in-plant workers and individuals living nearby. It may never be possible to test accurately the validity of this neighbourhood figure. Beryllium-using plants, recognizing a significant hazard since 1949, have moved some operations to more remote areas, have made use of stacks of great height, and have utilized dust collecting devices, thus eliminating the risk of neighbourhood beryllium poisoning.

Except for start-up operations, or a rare accident, high-level beryllium exposures have ceased in larger industries in the United States. New uses for beryllium, often in small plants or research laboratories where beryllium hazards are unknown, present a potential problem. The behaviour, which is still not entirely known, of small amounts of beryllium remaining in the body over long periods of time creates difficulties which are hard to judge.

In spite of these real questions, the rate of occurrence of cases of beryllium poisoning is steadily decreasing as the target levels of 25 $\mu g/m^3$ of air for a short, and 2 $\mu g/m^3$ of air for a chronic exposure are reached. There are far more data than is usual for safe levels to support the international use of these figures as M.A.C.'s of toxic beryllium compounds.

To assess the validity of M.A.C. in general and the beryllium levels here discussed, three things are essential on which this Congress could well take action:

(a) international occupational disease reporting; diagnostic criteria would have to be established by a panel of qualified experts;

(b) international agreement on assay methods;

(c) some scheme of follow-up experience, once figures agreed upon are put into practice.