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Case Report

Osteodystrophy after Inhalation of Radon-222

KURT WEGENER

Institute of Pathology of the University of Heidelberg (Head: Prof. Dr. W. Doerr)

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Summary. Multiple localised bone densities were radiographically spotted in a 68-year-old male patient who had worked for 5 years in uranium mines (Joachimsthal); they were diagnosed as metastases of a prostate carcinoma. After the autopsy we found by histological, radiochemical and autoradiographic investigations that a metastasizing prostatic carcinoma had not existed, but rather a "paget-like" osteodystrophia caused by deposits of radioactive decay products of inhaled Rn-222. Decay products are also likely to deposit in calcified atheroslerotic plaques.

The following paper is a report about a 68-year-old man, W.K., who had worked in the uranium mines in Joachimsthal from 1950—1955. At a clinical check-up in 1955 the patient's prostate was found to be hard. X-ray pictures showed focal densities in the spine, pelvis and right femur. A metastasizing prostate carcinoma was diagnosed. Bilateral orchidectomy was performed and the patient was subsequently treated with Progynon[1]. For 11 years, however, the bone lesions remained unchanged and were therefore reclassified as osteodystrophia deformans PAGET.

In 1966 the patient died of cardiac insufficiency. The autopsy revealed a partly atheromatous, partly calcifying atherosclerosis of the coronary arteries and extensive hypoxemic lesions of the heart muscle, particularly in the left ventricle. Although many histological sections (at 50 μ intervals) of the prostate were checked a carcinoma could not be detected. Neither bone metastases nor typical osteodystrophia deformans PAGET existed. Instead, the tissue structure of the densified regions of the bones showed an osteodystrophia containing small marrow spaces, a fibrous marrow, a few lacunae and dilatation of Haversian canals, which, however, lacked the typical mosaic structures of PAGETs disease (Fig. 1 a). There have been reports for quite some time on such bone lesions resulting from exposure to irridiation or radium and mesothorium poisoning accompanied by accumulation of radioactive isotopes in the bones (literature cf. Zollinger, 1960).

We therefore considered whether there might be a causal relation between the osteodystrophia described above and the incorporation of radioactive substances from the mines of Joachimsthal.

Rajewsky (1940), as well as Behounek and Fort (1941), reached the following conclusions based on radioactivity measurements on workers and test animals in the mines of Schneeberg and Joachimsthal:

1 Progynon®, Fa. Schering AG.

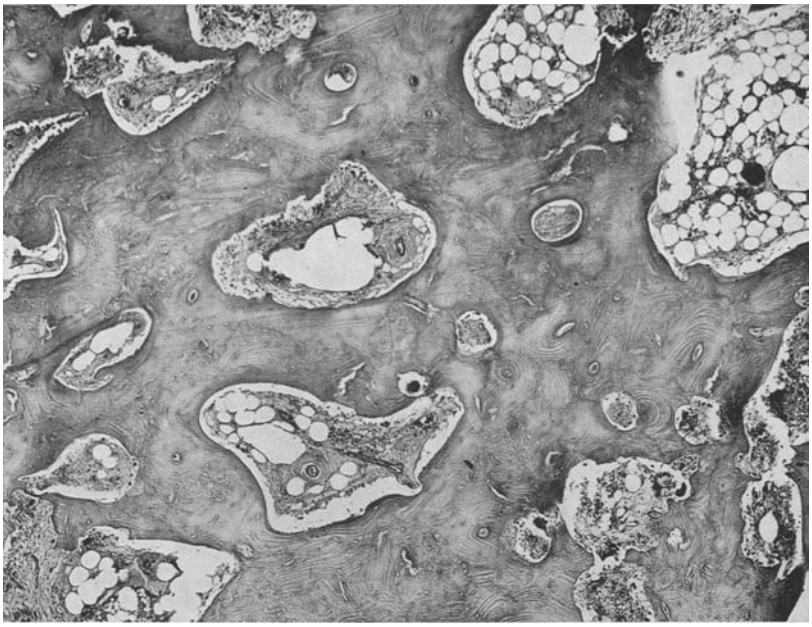

Fig. 1a. Osteodystrophic area of right femur with "paget-like" lesions. (Micrograph, HE, Magn. $\times 100$)

1. During underground work the body is saturated with radium emanation (Rn-222) by inhalation.

2. Rn-222 affects primarily the lungs. Its decay products are deposited mainly in the bones and the marrow of the spine, the ribs, the femur, the jaw and the skull.

3. The inhaling of Rn-222-containing air in the mines is likely to be one of the causes of the Schneeberg disease (60—70% lung cancer) as it was extensively described by Rostoski *et al.* (1931), Löwy (1929), Sikl (1930), Löwy *et al.* (1931) and Hueck (1940).

Rn-222 is the 7th decay product of the uranium-238 decay series. All of the decay products of Rn-222 (Po-218; Pb-214; Bi-214; Po-214; Bi-210; Po-210) have a short half-live except Pb-210, which has a half-live of 19.4 years. Therefore Pb-210 should be detectable even years after inhalation of Rn-222. Furthermore lead is an "osteotrope" metal, its metabolism being similar to that of calcium (Lomholt, 1930; Behrens and Baumann, 1933; Calhoun *et al.*, 1954; McLean, 1954).

We therefore tried to detect 1. Pb-210 in the densities of the bones and in the calcified regions of the coronary arteries using various techniques, and 2. the decay products of Rn-222 in the bones by means of autoradiography.

a) Lead was isolated by electrolysis from the ash residue of a densified piece of femur bone weighing 1.82 g. The lead fraction in the form of $Pb_3(PO_4)_2$ had an activity of 17.8 ipm above zero level (= activity of a control specimen prepared in the same manner). The difference in the impulse rate was statistically signifi-

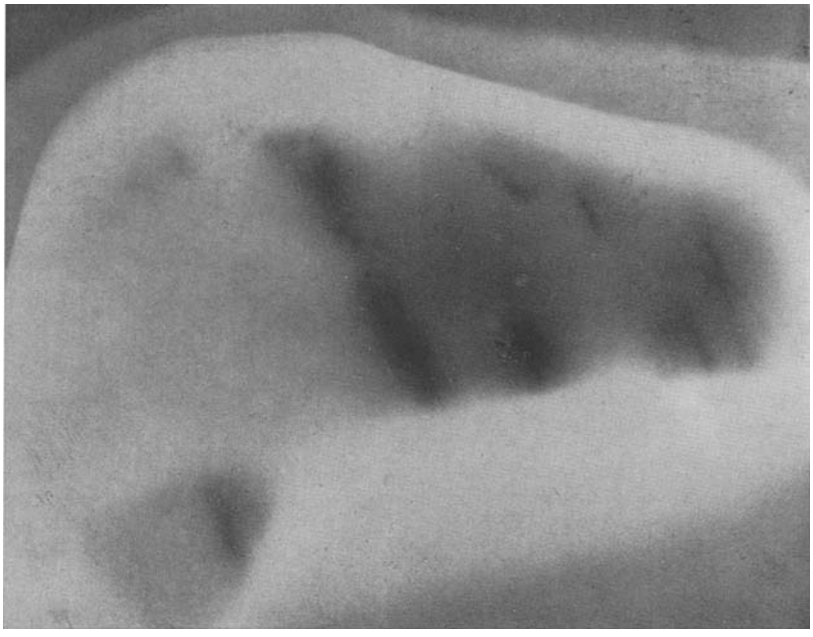

Fig. 1 b. Autoradiogram of right femur head. Extensive blackening of different intensity in densified areas. (Micrograph, Magn. × 1)

cant, the probability of error being smaller than 1.0% ($p = 0{,}01$)[2]. (The samples were measured in a liquid scintillation counter; Packard Instr. Comp.; Model 3375; Dioxan-Scintillator; the energy channel adjustment was the same as for tritium measurements, since the decay energy of Pb-210 ($E = 0.017$ MeV) is very close to that of tritium ($E = 0.018$ MeV)].

b) Bone samples of $30 \times 10 \times 12$ mm taken from densified areas and from a control case were fixed, freeze-dried, put into scintillation liquid, and measured (technical data cf. a). There was a statistically significant difference between the impulse rates of the test group and those of the control group, the probability of error being less than 0.1% ($p = 0.001$).

c) Samples of equal weight taken from calcified regions of the three coronary arteries and from a control case were fixed and freeze-dried. Then they were dissolved in Hyamine-10-X (Rohme and Haas, Inc.) (Rapkin, 1961) and measured in the liquid scintillation counter (technical data cf. a). The differences in the impulse rates of the test samples and the control samples were statistically significant, the probability of error being 0.1% ($p = 0.001$).

d) Thin saw cuts of several densified regions of bone and of control samples were fixed and freeze-dried. Afterwards they were directly covered with normal X-ray film and exposed at 4°C for 3—5 weeks. The X-ray film was blackened above the densified regions of bone whereas the corresponding control samples showed no effect (Fig. 1 b).

2 I am very grateful to Dr. W. Höpker, who was responsible for the statistical evaluations.

These results of our investigations permit the following conclusions: In the case described a prostate carcinoma with bone metastases were not found at autopsy as clinically presumed. The bone lesions in the form of a "paget-like" osteodystrophia, were caused rather by osteotrope decay products of inhaled Rn-222. Of these decay products Pb-210 could be detected by means of radiochemical methods. It was possible to localize radioactive substances in the densified regions of bone by autoradiography (most likely caused by several decay products of Rn-222). These decay products perhaps were deposited in calcified atherosclerotic lesions of the vessel wall as well. One individual case, however, can not be the basis for deciding whether the irridiation of radioactive decay products accelerates or intensifies atherosclerotic alterations of the vessel wall.

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Priv.-Doz. Dr. med. K. Wegener
Pathologisches Institut der Universität
D-6900 Heidelberg, Berliner Straße 5
Postfach 1368