POISONING FROM DRINKING RADIUM WATER

ALEXANDER O. GETTLER, PH.D.
AND
CHARLES NORRIS, M.D.
NEW YORK

Radioactive salts taken internally in the smallest traces are detrimental to health and fatal to life. This has been definitely proved by the work of Martland and his co-workers,[1] St. George, Gettler and Muller,[2] Hoffman,[3] Castle and Drinker,[4] Flinn [5] and the U. S. Department of Labor,[6] especially in connection with the series of radium watch dial workers in New Jersey.

The case to be described in this paper is interesting because it is the first one on record to be diagnosed correctly as radium poisoning, caused by drinking radium water, and in which the autopsy and analysis of the tissues corroborated the diagnosis.

Fig. 1.—Autophotographic appearance of femur.

From the chemical laboratories of Bellevue Hospital, the Chief Medical Examiner's Office, and Washington Square College, New York University.

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2. St. George, A. V.; Gettler, A. O., and Muller, R. H.: Radioactive Substances in a Body Five Years After Death, Arch. Path. **7**: 397-405 (March) 1929.

3. Hoffman, F. L.: Radium (Mesothorium) Necrosis, J. A. M. A. **85**: 961 (Sept. 26) 1925.

4. Castle, W. B.; Drinker, Katherine R., and Drinker, C. K.: Necrosis of the Jaw in Workers Employed in Applying a Luminous Paint Containing Radium, J. Indust. Hyg. **7**: 371 (Aug.) 1925.

5. Flinn, F. B.: Radioactive Material an Industrial Hazard? J. A. M. A. **87**: 2078-2081 (Dec. 18) 1926.

6. U. S. Department of Labor Bulletin: Radium Poisoning, 1929.

History.—E. M. B., a man, aged 52, weighing about 110 pounds (50 Kg.), markedly emaciated and anemic, was admitted to the hospital [7] and treated for necrosis of the jaw. He had been drinking a water (said to be "Radithor") for about five years. This water is said to have contained 2 micrograms of radioactive substances in each 2 ounce (60 cc.) bottle, and the patient had consumed about 1,400 bottles.

The patient was in the hospital a few months, and during this time the air he expired was found to be radioactive.[8] Four weeks before death a part of the necrotic jaw was removed by operation. The condition of anemia and emaciation increased continually, and at death he weighed only 90 pounds (41 Kg.).

TABLE 1.—*Total Amount of Radium in Bones and Tissues as Determined by the Emanation Method*

Tissues	Total Weight	Grams Used for Ashing	Per Cent Ash	Grams of Ash From Entire Tissues	Micrograms Ra per Gm. Ash	Micrograms Ra in Entire Body
Femur	...	10.5	51.3	....	0.0092	.....
Vertebrae	...	12.5	50.8	....	0.0342	.....
Rib	...	8.4	51.5	....	0.0039	.....
Jaw bone	...	6.8	44.2	....	0.0076	.....
Teeth	...	1.5	53.4	....	0.0149	.....
Average	...	....	50.2	....	0.0139	.....
Total skeleton	10,500*	....	50.2	5,271.00*	0.0139*	73.27*
Heart	250	50	0.9	2.25	0.0008	.....
Spleen	150	100	0.87	1.30	0.0009	.....
Kidneys	280	145	0.64	1.80	0.0046	.....
Liver	1,200	425	0.80	9.60	0.0012	.....
Lungs	600	540	0.82	4.92	0.0008	.....
Muscle, blood and remaining tissues	28,000*	...	....	224.24*	.....	.....
Average	...	...	0.8	....	0.0016	.....
Total soft tissues	30,480*	...	0.8	244.11*	0.0016*	0.39*
Total micrograms Ra in entire body						73.66*

* Estimated.

The autopsy [9] revealed necrosis of the jaw bones, swollen kidney cortex, cerebral abscess of the right temporosphenoidal lobe, moderate coronary sclerosis, moderate nodular sclerosis of the aorta, and marked hyperplastic bone marrow (regenerative type) (bright red bone marrow). The cause of death was necrosis of the jaw, abscess of the brain, secondary anemia and terminal bronchopneumonia. In order to prove the nature of the poison causing these conditions the heart, liver, lungs, spleen and kidneys, and portions of the femur, vertebrae, ribs, jaw bone and teeth were taken for analysis.

Fig. 2.—Radioactivity shown by jaw bone.

Preparation of Tissues.—The separate portions of the tissues as removed from the body were weighed and then ashed in an electric muffle. The ashes thus obtained were weighed, and the percentage of ash then calculated. The total weight of skeleton, muscle, blood and the like was estimated. All values obtained are given in table 1. The various ashes were examined by means of the electroscope.

7. Doctor's Hospital, New York, Service of Dr. Joseph S. Wheelwright.
8. Tests on expired air were made by Dr. F. B. Flinn of Columbia University.
9. Autopsy was performed by Dr. Charles Norris, chief medical examiner of New York City.

Electroscopic Tests.—The Lind electroscope was used throughout this work. The normal leak was first determined, by averaging several readings, and found to be 2,880 seconds for ten divisions on the scale. The bone and tissue ash were now successively introduced into the lower chamber of the electroscope, and the time for a ten division leak was determined. The time of leak was always read with the electroscope leaf between 6 and 8 of the scale, making the several readings strictly comparable. The results are indicated in table 2. The figures show an enormous reduction in the leakage time, produced by the bone ashes, indicating that they were strongly radioactive. The leakage time for the ashes of the soft tissues was much less; but still a decided decrease over the normal leak, indicating that the soft tissues also contained some radioactive substance. Bone and tissue ashes of nonradioactive cases gave practically the same values as the natural leak.

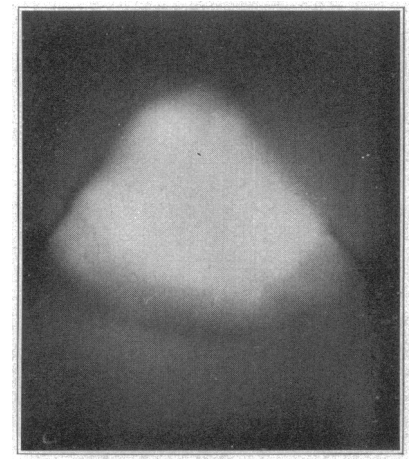

Fig. 3.—Image of vertebra.

Photographic Method for Detection of Radioactivity.—All operations were conducted in a dark room. The photographic films were wrapped and sealed in black photographer's paper. The various bone and the tissue ashes were placed on these films and were allowed to remain standing in this manner for ten days. After this period the films were developed and printed. The results are shown in the accompanying reproductions of the autophotographs. The images thus obtained are due to the beta and gamma rays emitted by the radium present in the bones and tissues. All the bones of this case, examined by the photographic method, showed that they were strongly radioactive. The soft tissues were only weakly radioactive.

TABLE 2.—*The Electroscopic Leaks Obtained for Bone Ash and Soft Tissue Ash*

Material Tested	Grams Used	Leak in Scale Division	Time in Seconds
Normal leak	Control	10	2,880
Femur	5.0	10	95
Vertebrae	6.0	10	24
Rib	4.0	10	268
Jaw bone	2.5	10	76
Teeth	0.5	10	255
Heart	0.2	10	2,360
Spleen	0.8	10	1,870
Kidneys	0.8	10	1,980
Liver	0.8	10	1,650
Lungs	0.8	10	1,400

Quantitative Determination of Radium Content of Bones and Tissues.—The Lind electroscope, which was used for the measurements, was calibrated by the emanation method.

A sample of carnotite ore weighing 1 Gm. and containing 1.51 per cent of uranium was placed in a 200 cc. round bottom flask into which 100 cc. of 1:1 nitric acid (saturated with barium nitrate) was added. The contents of the flask were then boiled, so as to expel all the emanation. With the content of the flask still at the boiling temperature, the flask was sealed, and the emanation was allowed to collect for a period of one week. After this time, the sealed flask was connected with a purifying train (to remove carbon dioxide, acid spray, and moisture) and the emanation was driven over into a previously evacuated ionization chamber. The emanation was allowed to stand in the chamber for three hours before measurements were begun, in order to allow it to come to equilibrium with its surroundings. The electroscope head was then mounted

on the ionization chamber and charged for fifteen minutes at 135 volts, and the rate of leak was determined. The average of several determinations gave 14.2 seconds for a ten division leak. Since the natural leak of the instrument is about 2,880 seconds per ten divisions, the latter is of no significance as a corrective factor.

Fig. 4.—Strong radioactivity shown by teeth.

Since the ore contained 1.51 per cent of uranium, the amount of uranium present was $1 \times 0.0151 = 0.0151$ Gm. of uranium.

The ratio of radium to uranium, that is, the amount of radium element in equilibrium with 1 Gm. of uranium, is accurately known, and has the value:

$$Ra/U = 3.33 \times 10^{-7}$$

It is known, however, that only 97 per cent of this amount gives off emanation, so that the corrected amount of radium equivalent to the aforementioned sample and measured as stated is:

$$\text{Radium} = 0.0151 \times 3.33 \times 0.97 \times 10^{-7}$$
$$\text{Radium} = 4.9 \times 10^{-9}$$

This amount of radium, then, gives the observed leak of ten divisions in 14.2 seconds.

One gram samples of ash, when available (otherwise smaller samples), were treated exactly the same as was the carnotite ore in the calibration. The rate of leak was determined in each case. From the calibration just described, it was found that 4.9×10^{-9} Gm. of radium causes a ten division leak in 14.2 seconds. Hence the radium content of this series was calculated by the following equations:

$$\frac{14.2}{\text{Leak time for 10 div. in sec.}} \times \frac{1}{\text{Wt. taken in Gm.}} \times 4.9 \times 10^{-9} = \text{Gm. Ra per Gm. of ash,}$$

or

$$\frac{14.2}{\text{Leak time for 10 div. in sec.}} \times \frac{1}{\text{Wt. taken in Gm.}} \times .0049 = \text{micrograms Ra per Gm. of ash.}$$

Table 1 shows the radium content of the bone ashes and tissue ashes as determined by this method. The total amount of radium estimated to be present in the entire body was 73.66 micrograms.

The history of this case, the symptoms developed, the postmortem studies and the physicochemical analyses clearly indicate that the radium present in the water consumed was directly responsible for the patient's death.

It might be questioned why more such cases as this one have not come to light. The answer lies in the following: First, radium water (that is, water actually containing traces of radium salts) are a little expensive and therefore cannot be used daily, for years, as a drinking water, except by the wealthy; and, second, the symptoms of radium poisoning are at present still little known by the average physician, and therefore the correct diagnosis is not often made.

SUMMARY

This paper presents the first case on record of fatal poisoning from the consumption of water containing traces of radium salts in which the presence of radium in the bones and tissues was definitely proved by scientific laboratory procedures.

Death was due to pathologic lesions brought about by the radium, which entered the system, by drinking water for a few years, which was said to contain 2 micrograms of radium in every 2 ounces (60 cc.) of water.

The presence of the radium was proved by both the electroscopic and the photographic method.

The quantity of radium in the bones and soft tissues was determined by the emanation method.

The entire skeleton contained 73.27 micrograms of radium, the soft tissues only 0.39 micrograms. The total amount of radium, therefore, in the entire body was 73.66 micrograms.

Radium salts (or radioactive substances in general), when introduced into the blood stream, become detrimental to health and fatal to life, and therefore the use of foods or beverages containing radium salts should be prohibited.

First Avenue and Twenty-Ninth Street.

CHRONIC SINUS DISEASE

ITS PRESENT STATUS

FERRIS SMITH, M.D.
GRAND RAPIDS, MICH.

The afflicted public and many of the profession feel that the management of chronic sinus disease is a failure. The public has been forced to this conclusion by multiple sad experiences and the physician to the same attitude by repeated disappointments. The phrase "once a sinus operation, always a sinus operation" is an axiom heard in every part of the country. This

Fig. 1.—Marked chronic inflammation; cystic degeneration of the gland.

fact results in frequent adverse advice from the general physician and is a challenge to every specialist in the profession.

The intimate etiologic relation of chronic sinus disease to the general manifestations of chronic infection, its extreme importance in the proper management of chronic bronchitis, and its frequent origin of bacterial