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Elimination of Radioactive Elements in Patients Who Have Received Thorotrast Intravenously.

WILHELM STENSTROM AND IRWIN VIGNESS.

From the Department of Radiology, University of Minnesota.

The radioactive method of determining the elimination of any elements in the thorium series is more sensitive than the chemical method and has been used exclusively in this study which deals with the elimination from patients who previously have received intravenous injection of thorotrast. Most of the ionization produced is caused by α-particles and preliminary studies indicated that an electroscope was the most suitable instrument for the detection of the ionization. The limit of the sensitivity of the method used was such as to detect 0.005 cc of thorotrast mixed with 4 g of ash. The γ-ray Geiger-Müller counter did not give a reliable response to less than 1 cc of thorotrast at 1 cm distance.

Apparatus and Method. A Wulf bifilar type of electrometer, which has a low capacity, was used in conjunction with a cylindrical ionization chamber 18 cm in diameter and 26 cm long. The chamber was attached directly to the electrometer.

In order to obtain a measure of the thoron in the breath, a patient exhaled through a rubber tube into a closed cylindrical metal container having a diameter of 30 cm and a height of 30 cm. Several small holes in the cover provided for the escape of the exhaust air. A copper wire with an active length of 21 cm extended along the axis of the container. It was insulated from the grounded container and kept at a negative potential of about 2000 volts and served to collect the radioactive deposit caused by the disintegration of the thoron. After the collection had been made for a time, the wire was transferred and used as the central collecting electrode of the ionization chamber on top of the electrometer. The lengths of time that the patients breathed into the container were between 1 and 2 hours, but more deposit would build up if this could be continued for longer time (up to 20 or 30 consecutive hours). The half life time of thoron is only 55 seconds and that of thorium A 0.1 second. The next element, thorium B, has, however, a half life time of 10.6 hours and will therefore make the wire active for a relatively long time after it has been deposited.

The stool was collected in a waxed cardboard container. This box with its content was placed in an iron (sand bath) dish and heated for about 5 hours until a light colored ash remained, usually weighing from 2 to 4 g. The ash was then spread evenly over a circular, light cardboard paper about 17 cm in diameter and having a central hole 4 cm in diameter.

The ash obtained from the urine was a heavy black fusable material which probably consisted of carbon contained in various salts. This ash was so bulky and heavy that the α-rays were largely absorbed and the unsatisfactory results obtained indicated that it will be necessary to extract the radioactive substances from the urine when the studies are continued.

Results. In order to obtain an idea of the sensitivity of the method, small amounts of thorotrast were mixed with 4 g of ash which then was heated and thoroughly stirred. Measurements of the radioactivity of ash containing different amounts of thorotrast are reproduced graphically in Fig. 1, where the discharge of the electroscope in scale divisions per minute is plotted against the known amount of thorotrast present in the ash. The 3 dots correspond to 0.01, 0.02, and 0.03 cc of thorotrast respectively.

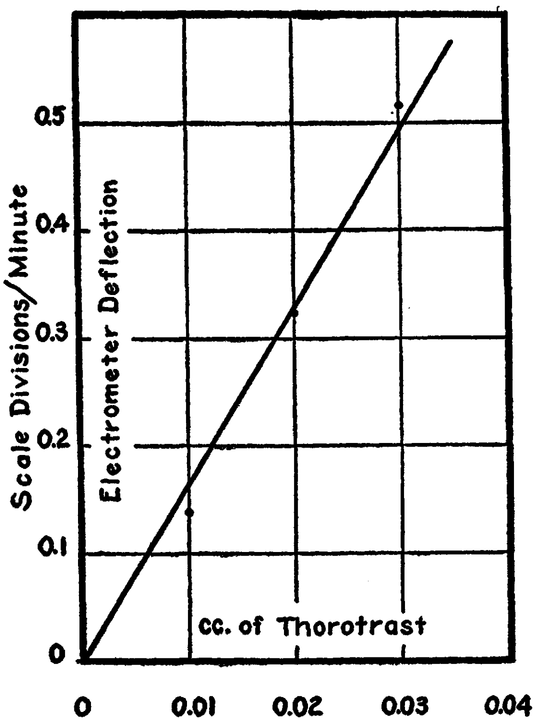

FIG. 1.

Examinations were made of the ashed feces from 2 patients who had intravenous injection of thorotrast 6 and 7 years previously. Each one had been given 75 cc of thorotrast which contained 24 to 26% thorium dioxide by volume. Easily measurable radioactivity was found in all the samples. When the samples were reëxamined several weeks later, it was, however, found that the radioactivity had almost completely disappeared. It was, therefore, assumed that most of the radioactivity was due to elements with short lifetime belonging to the thorium series. A stool obtained from the second patient at a known time was then ashed as soon as possible and its activity studied as a function of time. The results are plotted in Fig. 2. The points represent the number of scale divisions the electroscope was discharged per minute at different hours from the time the stool was collected. Curves A, B, and C were calculated from the known

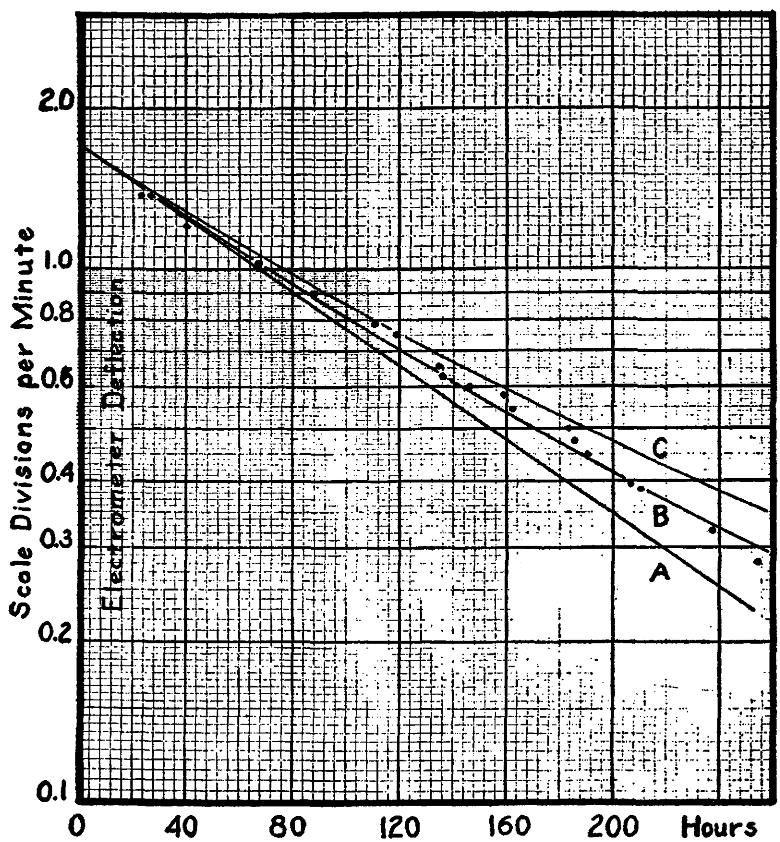

FIG. 2.

disintegration constants. Curve A shows the relation between radioactivity and time if only thorium X (half life time 87.4 hours) in equilibrium with its disintegration products was present, curve B shows the decay of a mixture of 95% thorium X and 5% of some preceding long lived product of the thorium series (thorium, mesothorium or radiothorium), and curve C illustrates a mixture of 91% thorium X and 9% long lived element. The radioactive elements present in the feces in this case seem to consist of approximately 95% thorium X and 5% of long lived elements, each in equilibrium with its disintegration products. A slight change in the normal background drift of the electrometer could, however, account for the difference between the curve representing thorium X and the experimental points. Measurements 4 months later indicate that 2 to 3% of the activity was due to long lived elements in equilibrium with their disintegration products.

Several samples of ashed feces from other individuals, who had never had any thorotrast injected, were also examined but in no case was any radioactivity discovered.

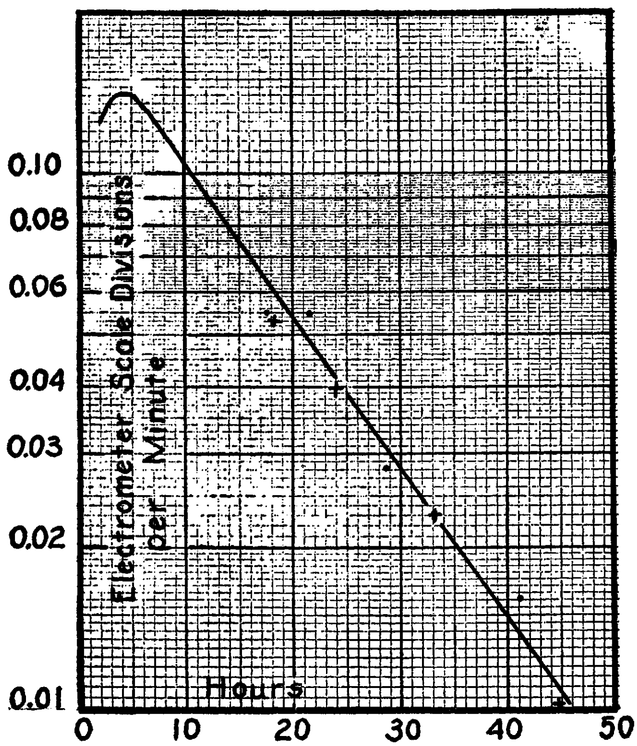

FIG. 3.

One sample of ashed urine from the second patient showed slight radioactivity which decayed with time. The patients were discharged before urine could be obtained for an attempt to extract the radioactive substances.

No radioactivity was discovered in one sample of sputum which had been collected over a period of 24 hours and then ashed. More sputum examinations ought to be done.

The results from one of the breathing experiments are shown in Fig. 3. The points fall very close to the theoretical curve for disintegration of thorium B and it is, therefore, evident that a fair amount of thoron is exhaled by the patient. This must mean that the thoron can pass rapidly from the source (probably liver and spleen) to the breath as the half life time for the thoron is only 55 seconds.

Summary. No excretion of thorium has thus far been discovered. Certain radioactive elements in the thorium series have, however, been found in the feces, urine and breath. Thorium X has been identified as the predominant element excreted in the feces, and thoron is definitely exhaled, as thorium B has been identified in the radioactive deposit from the breath. Such excretion of thorium X and thoron leads to reduced radioactivity in the body even if the thorium itself remains. As most of the γ-rays are emitted by disintegration products of thoron it is evident that the amount of thorium remaining in the tissues of a patient can not be determined with satisfactory accuracy by measurements of the γ-rays emitted from the patient (liver and spleen). During the disintegration process of some of the radioactive atoms such a displacement must take place that the newly formed atoms can escape.