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Note

Behaviour of the pertechnetate ion in humans

S.K. SHUKLA

Laboratorio Chimica Nucleare del C.N.R., Montelibretti, Casella Postale 10, Monterotondo Stazione, Rome (Italy)

and

G.B. MANNI and C. CIPRIANI

Reparto di Medicina Nucleare, Ospedale S. Eugenio, Rome (Italy)

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Ever since the availability on a large scale [1] of technetium-99 and its application in science and technology [2], followed by the increasing use of technetium-99m compounds in nuclear medicine [1—5], there has been great interest in the biological fate of this element in animals and humans and many workers [1, 3—10] have studied the problem. Studies have been concentrated mainly on the behaviour of the pertechnetate-99m ion, the most stable species of the metal, now in routine use in brain and thyroid imaging. For this purpose, the techniques of whole-body scanning [1], autoradiography [5], electrophoresis [6, 7] and chromatography [7] have been employed, and the last two techniques have been used to study the metabolism of pertechnetate-99m in the thyroid gland. The results obtained, however, have led to contradictory conclusions. Thus, Harper and co-workers [6, 10] found that, unlike iodide, pertechnetate is not organically bound in the thyroid, while electrophoretic and chromatographic evidence has indicated some organic binding of technetium-99m in rat thyroid [7, 8]. After entering the body, pertechnetate-99m ion is localized in the stomach and the salivary and thyroid glands [10]. Technetium-99m is excreted very rapidly in the urine, and urinary excretion has been shown to be the main path of technetium elimination for the first 3 days after administration [1, 10]. Hence the study of the composition of technetium excreted in urine should give an indication of whether or not pertechnetate-99m ion is organically bound during its passage through the body. The total activity being excreted, at different intervals, in urinary and faecal excreta has been measured

in order to establish the retention of technetium in the body but the excreta samples have not so far been analyzed to determine the technetium composition. As the half-life of technetium-99m is only 6 h, the excretion of this isotope can be taken to be mainly in urine. We therefore analyzed samples of urine collected from 37 patients admitted for thyroid or brain imaging and the results are reported here.

EXPERIMENTAL

Sodium pertechnetate-99m was eluted in saline from a Stercow TM 99m generator, supplied by Philips-Duphar, Petten, The Netherlands. Before injection, the radiochemical purity of the pertechnetate-99m ion was controlled by paper chromatography in physiological saline solution on Whatman 3MM paper strips (20 × 3 cm) with a chromatographic run of 15 cm. The chromatographic development was carried out by the ascending technique at room temperature (20°). Under these conditions, the pertechnetate-99m ion migrates with an R_F value of 0.68.

The total urine eliminated from the 37 patients during the post-injection period of 48 h was collected and examined. There were 25 euthyroid (of whom one was obese), 8 hypothyroid and 2 hyperthyroid patients of both sexes in the age range from 18 to 70 years. Two patients were injected with sodium pertechnetate-99m for brain scanning. The chemical form of technetium in the urine and in the blood serum of the patients was examined by paper chromatography and by low-voltage paper electrophoresis. The urine was stored at room temperature and was analyzed when fresh and when aged for different periods.

Paper electrophoresis was carried out at 400 V and 6—10 mA for 1 h on Whatman 3MM paper strips (30 × 3 cm) sandwiched between two thin glass plates.

After the run, the chromatograms and electropherograms were dried under a hair dryer and cut into 5-mm wide pieces. The activity in each piece of paper was counted with an automatic γ-counting well system (Model 4230, Nuclear-Chicago, Des Plaines, Ill., U.S.A.).

RESULTS AND DISCUSSION

The concentration of technetium-99m in the urine varied with the post-injection time, increasing rapidly to a maximum and then falling more slowly. The rate of urinary elimination of the nuclide for two patients is shown in Fig. 1. The trends of the curves are similar in the two examples, but for one the technetium-99m concentration in the urine reached a maximum 1 h after injection while for the other it took 3 h. The time required to give maximal activity in the urine from the other 35 patients was between these two limits of 1 and 3 h. This variation in the rate of elimination of technetium-99m was found to be due to the difference in the urine secretion rate, which was higher for the former patient than for the latter. A similar difference in the technetium-99m excretion has been reported by other workers [6]. These results

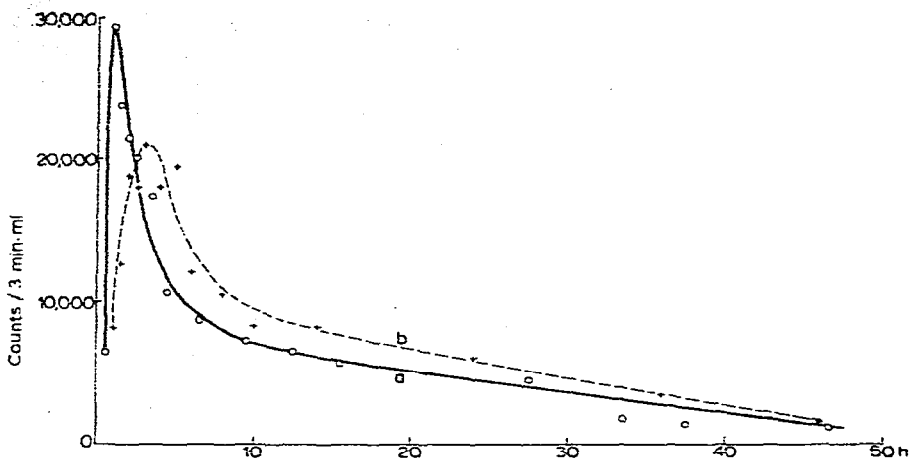

Fig. 1. Elimination, with time, of technetium-99m in the urine of (a) a patient with a higher urinary secretion (ca. 2.5 l/day) and (b) a patient with a lower urinary secretion (ca. 1.5 l/day) injected with sodium pertechnetate-99m in physiological saline.

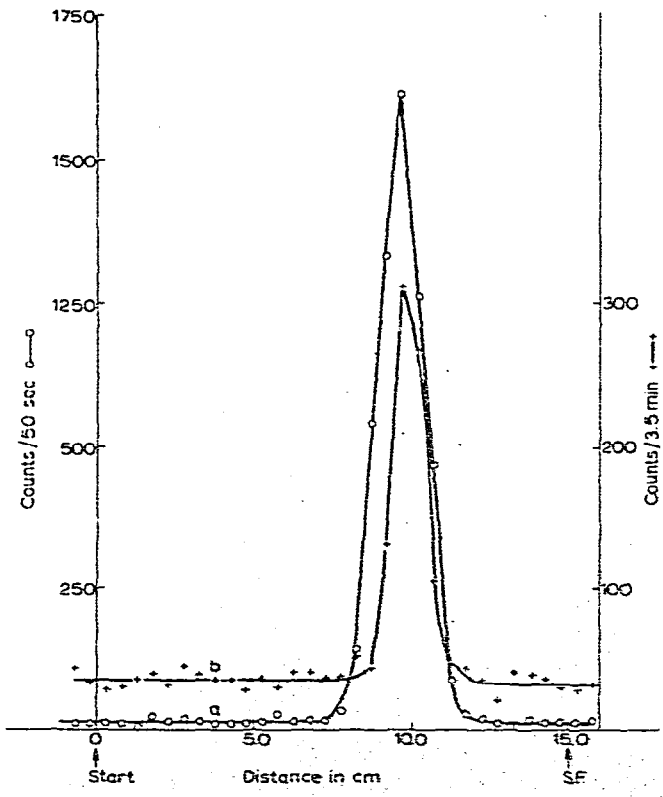

Fig. 2. Radiochromatogram (HCl-washed Whatman 3MM paper; mobile phase, physiological saline; temperature, 20°) of (a) injected sodium pertechnetate-99m in physiological saline and (b) technetium-99m in the urine of a hypothyroid patient (euthyroid patients' urine gives a similar radiochromatogram). S.F. = Solvent front.

suggest that after a scanning has been performed, the patient should drink a large volume of water in order to ensure the rapid elimination of the nuclide from the body in the urine.

Chromatographic and electrophoretic examinations of urine samples at different times after the injection of the radionuclide showed (Fig. 2) that the pertechnetate-99m ion is excreted unchanged in the urine of euthyroid and hypothyroid patients. The urine of patients admitted for brain scanning also contained only pertechnetate-99m ion. This result confirms the findings of Harper and co-workers [6, 10] that pertechnetate-99m is trapped in the organs of the body but is not organically bound. In hyperthyroid and obese patients, on the other hand, two other species of technetium-99m, one at the point of application and the other at an R_F value of 0.87, were also observed (Fig. 3). The chromatogram of blood serum of the hyperthyroid patients taken within 2 min after injection of the pertechnetate-99m ion also showed a similar technetium-99m distribution. These observations suggest that in hyperthyroid and obese patients pertechnetate-99m ion is partially metabolized when it comes in contact with the blood. In vitro studies with pertechnetate-99m in the blood and urine of these patients, however, did not show any modification in its

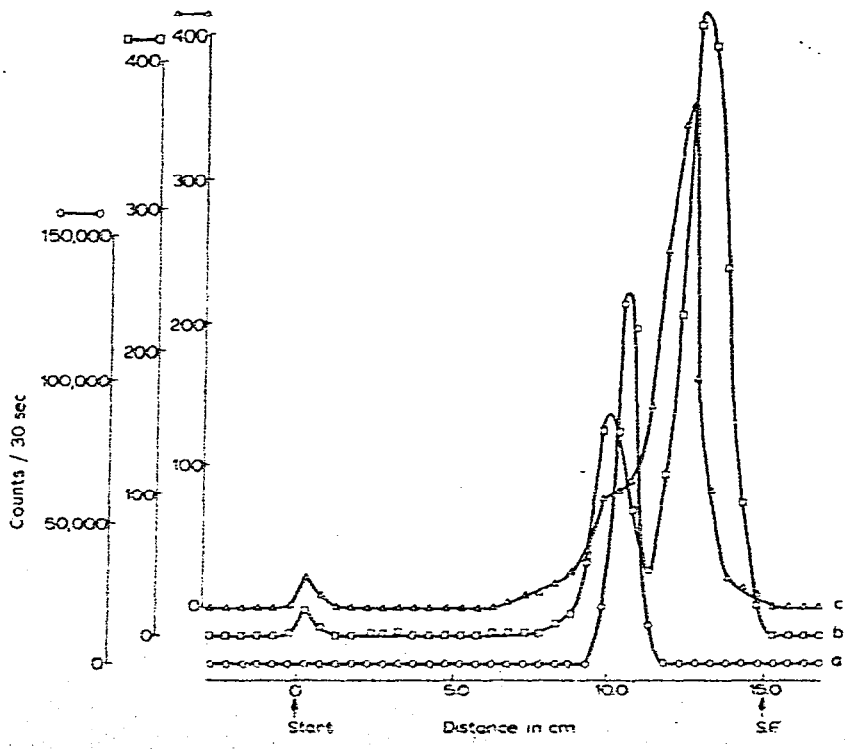

Fig. 3. Radiochromatogram (HCl-washed Whatman 3MM paper, mobile phase physiological saline, temperature 20°) of (a) injected sodium pertechnetate-99m in physiological saline, (b) technetium-99m in the urine of a euthyroid obese patient and (c) technetium-99m in the urine of a hyperthyroid patient. S.F. = Solvent front.

chemical form. We are continuing the studies with hyperthyroid and obese patients in order to obtain more data on the metabolization of pertechnetate-99m by studying the nature of these two technetium-99 species observed in chromatograms and electropherograms of urine and blood samples. Socolow and Ingbar [7], and Papadopoulos et al. [8] have also observed the metabolization of pertechnetate-99m in the thyroid gland of the rat, but the product was not characterized.

The results so far obtained on the chromatographic behaviour of the various species of technetium-99 [11, 12] and technetium-99m in solution [13] suggest that the species with $R_F \approx 0.87$ is technetium(IV)-99m and that at the point of application is organically bound technetium-99m [7].

REFERENCES

1 T.M. Beasley, H.E. Palmer and W.B. Nelp, Health Phys., 12 (1966) 1425.
2 K.V. Kotegov, O.N. Pavlov and V.P. Shvedov, Advan. Inorg. Chem. Radiochem., 11 (1968) 1.
3 P.V. Harper, G. Andros and K.A. Lathrop, Preliminary Observations on the Use of Six-hour ^{99m}Tc as a Tracer in Biology and Medicine, report ACRH-18, (1962) 76.
4 E.J. Baumann and N. Metzger, Proc. Soc. Exp. Biol. Med., 70 (1949) 736.
5 J.L. Quinn, III, The Year Book of Nuclear Medicine, Year Book Medical Publ., Chicago, Ill., 1975.
6 K.A. Lathrop, P.V. Harper, Jr., G.M. Hinn and G. Andros, Radiat. Res., 25 (1965) 210.
7 E.L. Socolow and S.H. Ingbar, Endocrinology, 80 (1967) 337.
8 S. Papadopoulos, S. MacFarlane and R. MacG. Harden, J. Endocrinol., 38 (1967) 381.
9 M. Welch, M. Adatepe and E.J. Potchen, J. Nucl. Med., 9 (1968) 358.
10 K.A. Lathrop and P.V. Harper, Progr. Nucl. Med., 1 (1972) 145.
11 S.K. Shukla, J. Chromatogr., 21 (1966) 92.
12 L. Ossicini and S.K. Shukla, Chimica del tecneto in soluzione, estratto del volume: "Metodologie analitiche ed equilibri in soluzione", convegno tenuto al C.N.R., Roma, 13-14 gennaio 1967. Consiglio Nazionale delle Ricerche, Roma, 1968, p. 103.
13 S.K. Shukla, in preparation.