Radiation Dosimetry from Breast Milk Excretion of Radioiodine and Pertechnetate

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Measurements were made of the activity in samples of breast milk obtained from a patient with postpartum thyroiditis following administration of [^{123}I]sodium iodide and subsequently [^{99m}Tc]pertechnetate 24 hr later. Both ^{123}I and ^{99m}Tc were found to be excreted exponentially with an effective half-life of 5.8 hr and 2.8 hr, respectively. Less than 10% of the activity was incorporated into breast-milk protein. After administration of [^{123}I]sodium iodide breast feeding should be discontinued for 24–36 hr to reduce the absorbed dose to the child's thyroid.

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When radiopharmaceuticals are administered to a lactating mother, the recommended practice is to interrupt breast feeding for a period of time, which is determined by the radionuclide and its chemical form. For technetium-99m- (^{99m}Tc) labeled products as well as [^{131}I]hippuran and [^{125}I]hippuran, breast feeding is usually resumed within 24 hr (*1–6*). However, the time delay may extend to 14 days for [^{67}Ga]citrate (*7,8*) or to 21 days for [^{125}I]fibrinogen (*9*).

The activity concentration in breast milk following administration of iodine-123 (^{123}I) sodium iodide has been measured as a function of time. In addition, the patient was subsequently injected intravenously with [^{99m}Tc] pertechnetate, allowing a direct comparison in the excretion rates of the two radionuclides.

CASE REPORT

A 33-yr-old white woman with suspected postpartum thyroiditis was referred for a thyroid uptake and scan. The patient was 7-wk postpartum and was breast feeding. Physical examination revealed a diffusely enlarged, nontender thyroid gland. Thyroid function studies were performed with the following results: TSH, <0.5 μU/ml (normal = <8 μU/ml); RT3U, 1.18 (normal = 0.88–1.20); T4-RIA, 15.5 μg % (normal = 4.5–11.5 μg %); antithyroglobulin antibodies, 1:5,120; antimicrosomal antibodies, 1:6,400; and free thyroxin index, 18.3 (normal = 3.96–13.00). The patient was given 183 μCi (6.8 MBq) [^{123}I]sodium iodide. The 6-hr and 24-hr uptakes were both <1% and, consequently, the thyroid gland could not be imaged. The patient was then injected intravenously with 2.5 mCi (92.5 MBq) [^{99m}Tc]pertechnetate. There was no significant accumulation of pertechnetate by the thyroid gland. The poor uptake of iodine and pertechnetate by the thyroid gland as well as elevated T4-RIA and antibody levels were consistent with a diagnosis of postpartum thyroiditis (*10,11*).

Breast feeding was discontinued for 48 hr following the administration of [^{123}I]sodium iodide. Milk samples were obtained at the child's regular feeding times using a mechanical breast pump. In the 24 hr following administration of [^{123}I] sodium iodide and prior to the administration of [^{99m}Tc] pertechnetate, five samples were obtained. In the next 24 hr, six samples were collected. Two aliquots of 1 ml each from each breast milk sample were assayed in a 2 in. × 2 in. sodium iodide scintillation well counter. The counting system was calibrated using a cobalt-57 standard by applying a correction for different emission frequencies. The measured activity was corrected for decay in order to determine the activity at the time of collection. The fraction of activity bound to breast milk protein for each sample was determined by precipitating the protein with trichloroacetic acid (*12*).

RESULTS

Figure 1 shows the fraction of administered activity that was present per milliliter of breast milk as a function of time after administration of the radiopharmaceuticals. The concentration of ^{123}I decreased exponentially after reaching a maximum concentration 6 hr postingestion. The effective excretion half-life was 5.8 hr, which corresponded to a biologic half-life of 10.4 hr. Approximately 2.6% of the total activity was excreted in the milk assuming the breast milk output was 850 ml per day (*13*) and the temporal dependence of the activity concentration is described by the fitted exponential function.

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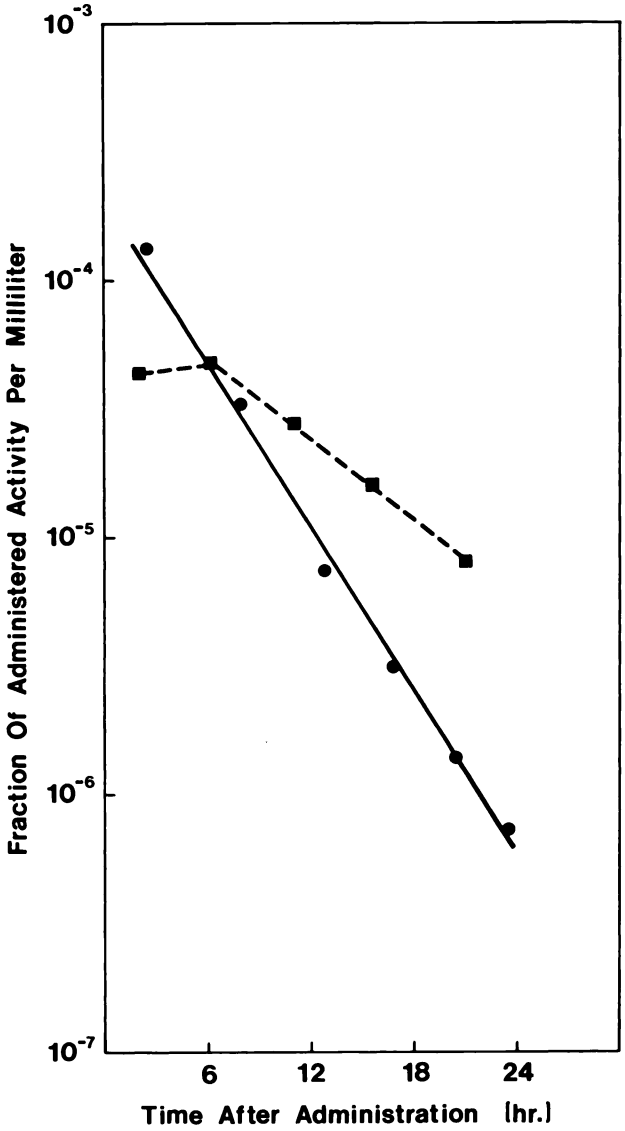

FIGURE 1
Fraction of administered activity which was present per ml breast milk at various times following administration of radiopharmaceuticals. (●) = [^{99m}Tc] pertechnetate; (■) = [^{123}I]sodium iodide

The ^{99m}Tc activity per milliliter of breast milk also followed an exponential curve, which resulted in an effective excretion half-life of 2.8 hr. Correcting for radioactive decay, the biologic half-life was 5.2 hr. The total excreted fraction of the injected activity was 2.5%. With one exception of 11%, the total excreted fraction of ^{99m}Tc pertechnetate has been shown to be 1% or less (*1,4,14,*15).

The fraction of the activity incorporated into breast-milk protein was 0.08 ± 0.02 and 0.07 ± 0.03 for ^{123}I and ^{99m}Tc, respectively. This determination represents the upper limit for isotope incorporation into protein, since no correction has been made for the nonspecific inclusion of soluble isotope into the protein precipitate. The fraction incorporated for both isotopes was constant with time after administration. Similarly, Mattsson et al. have reported that the ^{125}I present in breast milk following injection of ^{125}I fibrinogen was in the form of free iodine (*9*). The incorporation of ^{99m}Tc into breast-milk protein has also been demonstrated to be small (*2,5*).

The potential absorbed dose to the child has been calculated according to the schema of Loevinger and Berman (*16*). An intake of 850 ml breast milk per day given in equal fractions is assumed. Iodine-123 and ^{99m}Tc are both considered to be in ionic form. For oral administration of ^{99m}Tc, Ahlgren et al. have modified the biokinetic data given for the adult (*17*) in order to derive organ doses to the child per unit of ingested activity (*1*). In the case of ^{123}I S-values for newborns are given by Kerieakes and Rosenstein (*18*) and the biokinetic data for the adult presented in MIRD Dose Estimate Report No. 5 (*19*) have been extrapolated for a thyroid uptake of 50% (*20*). A removal rate of 0.7 hr^{-1} has been assumed for the stomach so that an additional component of the absorbed dose to the stomach wall could be calculated for the oral administration of the radioisotpe (*21*). The cumulated activity in the thyroid was determined to be 6.9 μCi-hr per μCi ingested. If a 50% immediate uptake and a biologic half-life of 14 days is utilized (*20*), the cumulated activity would be 9 μCi-hr per μCi ingested. The assumption of immediate uptake would overestimate the cumulated activity and, thus, the absorbed dose to the thyroid.

The absorbed dose to various target organs per unit activity ingested are summarized in Table 1. The absorbed dose delivered to the thyroid per unit activity of ^{123}I is 130 mGy/MBq, which differs from the previously reported value of 43 mGy/MBq (*22–24*). A thyroid uptake of 27% corresponding to a cumulated activity of 3.6 μCi-hr and a thyroid mass of 1.5 g were assumed for the latter dose determination.

If the patient's infant had continued breast feeding, then the total-body absorbed dose would have been 0.1 mGy (10 mrad) and the absorbed dose to the thyroid and stomach wall would have been 25 mGy (2.5 rad) and 8 mGy (0.8 rad), respectively.

DISCUSSION

The total activity of ^{123}I excreted in the breast milk by this patient represents the upper limit anticipated for the general population. Since the thyroid gland demonstrated essentially no uptake of radioiodine, a much larger fraction of the administered activity is available for excretion. Similarly, the administration of [^{99m}Tc]pertechnetate, which is less likely to concentrate in the thyroid gland, resulted in an activity concentration in the breast milk in the high range of the reported values.

TABLE 1
Absorbed Dose to Child per Ingested Activity

Target organ	^{99m}Tc Absorbed dose (mGy/MBq)*	^{123}I Absorbed dose (mGy/MBq)
Thyroid	1.0	130
Stomach wall	3.3	3.2
Total body	0.04	0.14

* From Ahlgren et al., Ref. (*1*).

Several considerations indicate that breast feeding should be discontinued for a longer period of time following administration of [^{123}I]sodium iodide compared with [^{99m}Tc]pertechnetate. The physical half-life as well as the biologic half-life are longer for ^{123}I. In addition, a high percentage of the ingested radioiodine will locate in the thyroid gland of the child. By interrupting breast feeding for 24 hr, the thyroid absorbed dose would be reduced to ~6% of the potential absorbed dose, which corresponds to 1.4 mGy (140 mrad). If breast feeding were discontinued for 36 hr, the thyroid absorbed dose would decrease to ~1% of the potential absorbed dose (0.2 mGy or 20 mrad).

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