Human Breast Milk Excretion of Iodine-131 Following Diagnostic and Therapeutic Administration to a Lactating Patient with Graves' Disease

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Previous reports on the excretion of ^{131}I into human breast milk have recommended discontinuance of breast feeding from 1 to 12 days following diagnostic tracer doses of ^{131}I. Recent excretion models have calculated that breast feeding could safely resume 56 days following a 5 μCi (0.185 MBq) ^{131}I maternal tracer dose. We studied a postpartum patient with Graves' disease following first an uptake dose of 8.6 μCi (0.317 MBq) and then for 38 days following a 9.6 mCi (355 MBq) therapy dose of $Na^{131}I$. We calculated from our data that although nursing could not be safely resumed for 46 days following the 8.6-μCi uptake dose, nursing could resume in this patient 8 days after a 100-nCi (3.7 KBq) dose. Extrapolating this data to impure ^{123}I (p, 2n or p, 5n) we feel that standard 100-μCi (3.7 MBq) doses of either ^{123}I preparation is not suitable if nursing is to be resumed.

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Several brief reports in the past have studied the excretion of iodine-131 (^{131}I) into human breast milk (*1–5*). From these reports recommendations have evolved to discontinue breast feeding for 24 hr (*3*), 10 days (*4*), and 12 days (*5*) following diagnostic tracer doses up to 200 μCi (7.4 MBq) of ^{131}I. Romney et al. (*6*) assuming that 1 wk following tracer administration, breast milk concentrations (μCi/ml) would equal the dose (μCi) × 10^{-5}, and that from that point on breast milk concentrations would decrease with an effective half-life of 8 days, (biologic half-life = ∞), recommended that breast feeding could resume 56 days following a 5-μCi (0.185 MBq) tracer dose to the mother. In order to test Romney's assumptions and because the concentrations of ^{131}I in breast milk had not been followed for more than 12 days (*4*), a postpartum patient with Graves' disease was studied for 38 days following a 9.6-mCi (355 MBq) dose of $Na^{131}I$.

MATERIALS AND METHODS

Patient

A 30-yr-old woman with Graves' disease in remission for 18 mo following propylthiouracil therapy developed recurrent symptoms of hyperthyroidism 4 mo postpartum. A diffuse 35-g goiter was palpated. Laboratory evaluation revealed T4IA = 16 mcg/dl (normal 4–10 mcg/dl), T3IA = 364 ng/dl (normal 82–202 ng/dl), and T3U = 56% (normal 37–53%). Nursing was discontinued and a radioactive iodine uptake (8.6 μCi (0.317 MBq) ^{131}I sodium iodide, orally) was 23% (4 hr) and 44% (24 hr). Nine days following the uptake scan a 9.6 mCi (355 MBq) therapeutic dose of ^{131}I sodium iodide was administered orally.

Milk Samples

Breast milk samples were obtained periodically following both the uptake and therapeutic (Fig. 1) dose administrations by a breast pump and placed in 50-ml sterile centrifuge tubes. The milk was resuspended to ensure homogenicity and a 1-ml aliquot was pipetted into a counting tube.

Samples were counted in a well counter within 7 days of collection, counting efficiency was determined at the same time and breast milk concentration was reported in μCi/ml of breast milk as of the date of breast milk collection.

Dosimetry Calculations

Assuming that nursing begins during the second component of the breast milk excretion curve (Fig. 1), radiation dosimetry to the critical organ (thyroid gland) as outlined by Romney (*6*) is:

$$\text{Cumulative dose (rad)} = T_{eff} \times C \times V \times D \quad (1)$$

T_{eff} = Effective half-life of the tracer in breast milk (days);
C = activity concentration in breast milk at time of safe

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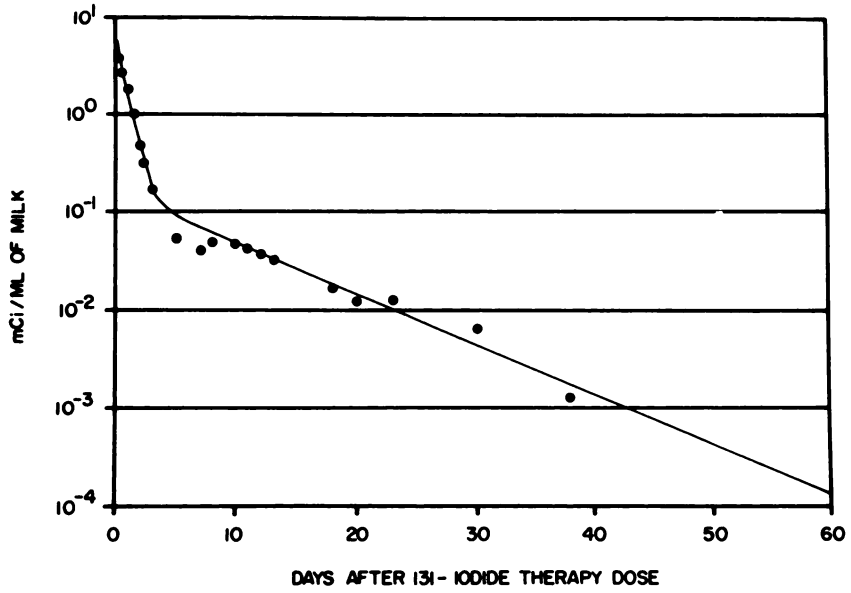

FIGURE 1
Concentration of ^{131}I in breast milk (μCi/ml) as a function of time (days) following a therapeutic administration of $Na^{131}I$ (9.6 mCi). Breast milk concentration (μCi/ml) = $6.35e^{-1.49t(days)} + 0.15e^{-0.12t(days)}$; r = 0.995.

resumption of nursing (μCi/ml);

V = Daily volume of ingested milk (ml);

D = Radiation dose (rad) to the critical organ (thyroid gland) per μCi tracer (^{131}I) ingested (rad/μCi);

rad/μCi = 3.7×10^{-3} mGy/MBq.

Alternatively, this equation can be expressed in terms of that breast milk concentration which will produce the maximum permissible cumulative radiation dose (MPD) to the critical organ (*6*):

$$C = \frac{\text{MPD (Rad)}}{1.44 \times T_{eff} \times V \times D} \quad (2)$$

Although adequate data on breast milk consumption is not available, recommended daily milk intake during the first 6 months of life is 150 to 200 ml/kg (e.g., 1,000 to 1,500 ml/day for a typical 7.5-kg, 6-mo-old infant) (*7*). At this time, milk intake stabilizes. For this reason, 1,500-ml daily milk volume (V) was assumed as a conservative estimate.

Wellman in 1970 (*8*) originally reported the newborn thyroid dose factor as 21 rad/μCi (5.7 Gy/MBq) of ^{131}I ingested. In 1971 (*9*) he modified this to 16 rad/μCi (4.3 Gy/MBq) for the newborn and 10.9 rad/μCi (2.95 Gy/MBq) for the 1-yr-old infant. This newborn thyroid dose factor has been accepted by the National Council on Radiation Protection and Measurements (*10*). Recently Hedrick (*11,12*) suggested that even this dose is considerably underestimated. In our calculations we used 16 rad/μCi (4.3 Gy/MBq).

The maximum permissible dose (MPD) is taken to be 1/10 of the yearly MPD to the thyroid as established by the ICRP. The ICRP recommends a limit of 1.5 rad/yr (15 mGy/yr) for children under 16 yr of age and in our calculations we limit exposure to one-tenth this amount or 0.150 rad (1.5 mGy) (*13*).

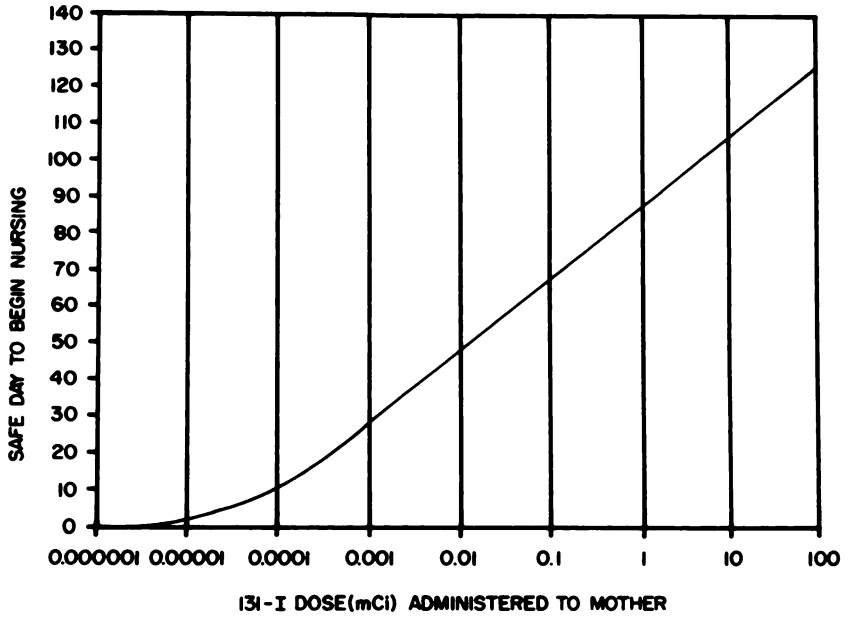

FIGURE 2
The minimum delay to the safe resumption of nursing as a function of the amount of $Na^{131}I$ activity (mCi) administered to the mother.

RESULTS

The radioiodine breast milk concentration following the therapy dose peaked within 6 hr and decreased exponentially for the first 3 days with an effective half-life = 11.1 hr (biologic half-life = 11.8 hr), and subsequently continued to decrease exponentially with an effective half-life = 5.9 days (biologic half-life = 21.9 days). Equation (3), the milk excretion curve (Fig. 1) was derived by least squares dual exponential regression analysis of the therapy dose data.

$$\text{Breast milk concentration } (\mu\text{CI/ml}) = \frac{\text{dose(uCi)}}{9600}\left(6.35e^{-1.49t(\text{days})} + 0.15e^{-0.12t(\text{days})}\right) \quad (3)$$

r (therapy dose) = 0.995

The 8.6-μCi uptake dose excretion data correlated well with Eq. (3), (Table 1, r = 0.98) although the second (slow) component of the curve was not evaluated with only two days of data.

Using Eq. (2) (T_{eff} = 5.9 days), nursing may resume when breast milk ^{131}I concentration declines to 7.36×10^{-7} μCi/ml. From Eq. (3) this would occur on Day 46 for the 8.6-μCi (0.317 MBq) uptake dose and on Day 106 for the 9.6-mCi (355 MBq) therapy dose. If the uptake dose were reduced to 5 μCi (0.185 MBq), nursing could not resume until the 40th day, and for a 1-μCi (0.037 MBq) dose, until the 28th day. However, if the dose were reduced to 0.1 μCi (3.7 kBq), nursing could resume in this patient as early as the eighth day (Fig. 2).

DISCUSSION

Previous reports (*3–5*) had recommended from as short as 24 hr to as long as 10 days as the appropriate time to delay nursing following administration of microcurie quantities of ^{131}I. The analyses either ignored the second (slow) component of the biexponential breast milk disappearance curve (*3,5*) or severely underestimated it (*4*). Romney (*6*) recognized the biexponential nature of the breast milk ^{131}I disappearance curve and by assuming that the effective half-life of the second (slow) component of this curve equals the physical half-life of the isotope (i.e., biologic half-life = ∞), he calculated that the minimum time to the resumption of nursing would be 56 days following a 5-μCi (0.185 MBq) dose. He concluded that this length of time was impractical and recommended that ^{131}I should not be utilized for women who desire to nurse.

The most common reason for radioiodine testing postpartum is to diagnose postpartum thyroiditis and to distinguish this entity from or to evaluate Graves' disease. Since a radioiodine uptake can be accurately performed with as little as 0.1 μCi (3.7 kBq) ^{131}I, and following this dose nursing could be resumed in 8 days, we suggest this dosage of Na ^{131}I for studies in those post partum patients who wish to resume nursing. Following this dose breast milk samples could be obtained from the fourth day on, the "slow" component effective half-life calculated, and using Eq. (2) the breast milk concentration following which nursing may safely resume can be determined. Then nursing will resume when this level has been reached.

Since [^{99m}Tc]pertechnetate uptake and/or scanning can be used to evaluate hyperthyroidism (*14*) following which nursing can be resumed in 24 hr (*6*), we recommended that ^{131}I be avoided if nursing is to be resumed.

Romney (*6*) stated recently that nursing need only

TABLE 1
Concentration of ^{131}I in Breast Milk (μCi/ml) Following a Diagnostic Administration of 8.6 μCi (0.317 MBq) of Na ^{131}I

Sample post dose (days)	Concentration in breast milk ($\times 10^{-3}$ μCi/ml)
0.16	2.65
0.33	4.92
0.5	2.73
0.83	0.99
1	0.70
2	0.15

TABLE 2
Concentration of ^{131}I in Breast Milk (μCi/ml) Following a Therapeutic Administration of 9.6 mCi (355 MBq) of Na ^{131}I

Sample post dose (days)	Concentration in breast milk (μCi/ml)
0.25	3.909
0.5	2.704
1	1.845
1.5	1.023
2	4.85×10^{-1}
2.25	3.16×10^{-1}
3	1.69×10^{-1}
5	5.4×10^{-2}
7	4.1×10^{-2}
8	4.9×10^{-2}
10	4.7×10^{-2}
11	4.2×10^{-2}
12	3.6×10^{-2}
13	3.2×10^{-2}
18	1.7×10^{-2}
20	1.23×10^{-2}
23	1.27×10^{-2}
30	6.63×10^{-3}
38	1.3×10^{-3}

TABLE 3
Required Nursing Delay Following Various Dosages of ^{123}I*

Isotope	Dose	Contaminant	Nursing delay†	Nursing delay‡
^{123}I (p, 2n)	100 μCi	^{124}I§-4.8%	20 days	26
	100 μCi	^{124}I-2%	15	21
	100 μCi	^{124}I-1%	12	18
	100 μCi	^{124}I-0.5%	9	15
	30 μCi	^{124}I-4.8%	14	20
	30 μCi	^{124}I-2%	10	16
	30 μCi	^{124}I-1%	6	12
	30 μCi	^{124}I-0.5%	5	9
^{123}I (p, 5n)	100 μCi	^{125}I§-1.9%	112	126
	100 μCi	^{125}I-1%	97	111
	100 μCi	^{125}I-0.5%	81	85
	100 μCi	^{125}I-0.1%	43	57
	30 μCi	^{125}I-1.9%	84	96
	30 μCi	^{125}I-1%	69	83
	30 μCi	^{125}I-0.5%	53	67
	30 μCi	^{125}I-0.1%	15	29

* Calculations based on Eqs. (2) and (3) (see text).
† Radiation dose (D) = ^{124}I-10.3 rad/μCi, ^{125}I-16.4 rad/μCi (*10, 16*) (Dydek).
‡ Radiation dose (D) = ^{124}I-36 rad/μCi, ^{125}I-30 rad/μCi (*12*) (Hedrick).
§ Teff = ^{124}I-3.5 days, ^{125}I-16.1 days (see text).
MPD = 0.150 rad (see text).

be suspended for 3 days following a 30-μCi (1.1 MBq) ^{123}I dose. Hedrick (*11,12*) as recently as April, 1987 similarly has recommended a 3-day cessation of nursing following administration of ^{123}I. Currently available 100-μCi (3.7 MBq) ^{123}I (p, 2n) capsules contain as much as 4.8% ^{124}I contamination (Medi-Physics, Inc., Emeryville, CA). Following this dose, using Eqs. (2) and (3) (T_{eff} = 3.5 days) nursing should not resume for 20 days (Table 3). "Clean" ^{123}I (p, 5n) may contain as much as 1.9% ^{125}I (*15*). Following a 100-μCi (3.7 MBq) dose, (T_{eff} = 16.1 days) a delay of 112 days to nursing would be required (Table 3). Therefore, we recommended that until ^{123}I can be produced relatively contaminant free, ^{123}I should be avoided in those patients who wish to resume nursing.

Since data has not previously been available regarding the actual nature of milk disappearance curves of ^{131}I, we studied this Graves' disease patient for 38 days following her therapy in order to determine the exact nature of the dual exponential disappearance curve. Because the effects of hyperthyroidism may make iodine metabolism not comparable to other patients, euthyroid and hypothyroid patients need to be similarly studied.

DISCLAIMER

The opinions and assertions contained herein are the private views of the authors and are not to be construed as reflecting the views of the Army or the Department of Defense.

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