Reevaluation of the Newborn Thyroid Dose from Radioiodines

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The basis for the current thyroid absorbed dose estimates for radioiodines has been examined. The values for the newborn thyroid dose were found to underestimate the dose by a factor of 3. This underestimation of the dose was caused by the assumption that the biokinetic distribution of iodine is the same for the newborn and the adult. Increased thyroid uptake by the newborn requires that higher cumulated activities be incorporated into the dose determinations for the newborn.

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The generally accepted values for the thyroid absorbed dose per unit administered activity for various radioisotopes of iodine were determined by Wellman and Anger (*1*). The values calculated for the newborn utilize a thyroid mass of 1.5 g and thyroid uptake of 27%, which was assumed to be the same as that for the adult. The newborn period is generally considered to be the first 4 wk of life. The thyroid uptake changes markedly during the newborn period ranging from 70% to 80% immediately postpartum to 30% by the second week (*2*).

The radiation dose estimates for the newborn are strongly dependent on the assumed thyroid uptake. After the second week, the newborn thyroid uptake is similar to that of the adult. With this stipulation, the absorbed dose determinations presented by Wellman and Anger (*1*) are correct. However, the absorbed doses for the newborn calculated by Wellman and Anger have subsequently been reported with a thyroid uptake of 70% (*3,4*). High cumulated activities associated with this increased thyroid uptake have not been incorporated into the dose calculations. This oversight has resulted in an underestimation of the dose and has created an inconsistency in the radiation dose estimates for the newborn.

METHODS

The thyroid absorbed dose was calculated according to the schema of Loevinger and Berman (*5*). Values of the absorbed fractions were obtained from tables of absorbed fractions for small unit-density ellipsoids surrounded by a scattering medium calculated by Ellett and Humes (*6*). Total equilibrium dose constants were calculated from the work of Dillman and Von der Lage (*7*). The convention of designating photons below 11 keV as nonpenetrating was used. The thyroid mass of the newborn was assumed to be 1 g. The cumulated activity was determined for a thyroid uptake of 50% (*8*) by extrapolating the biokinetic data for the adult presented in MIRD Dose Estimate Report 5 (*9*). The cumulated activity was also calculated for an immediate thyroid uptake of 70%.

In the case of iodine-123 (^{123}I) and iodine-131 (^{131}I), S values for newborns are given by Kereiakes and Rosenstein (*10*). A thyroid mass of 1 g was used in these S-value determinations.

RESULTS

The newly calculated newborn thyroid dose for each radioisotope of iodine are compared with the previously published values in Table 1. The increase in the thyroid dose per administered activity is a consequence of the higher assumed thyroid uptake and the reduced thyroid mass.

Using the S values for newborns given by Kereiakes and Rosenstein (*10*), the thyroid dose assuming 50% uptake is calculated to be 0.48 rad/μCi and 54 rad/μCi for ^{123}I and ^{131}I, respectively.

DISCUSSION

The rate of elimination influences the thyroid absorbed dose. The biologic half-time can vary greatly ranging from 21 days to 200 days (*11*). Iodine-125 with a relatively long half-life is most sensitive to changes in

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TABLE 1
Absorbed Dose Estimates to Newborn Thyroid per Administered Activity (rad/μCi)

Radionuclide	27% Uptake* (1.5)†	50% Uptake (1.0)†	70% Uptake (1.0)†
^{123}I	0.16	0.48	0.90
^{125}I	11	30	39
^{131}I	16	54	75
^{132}I	0.16	0.69	2.7

* Wellman and Anger, Ref. (*1*).
† Thyroid mass in grams.

elimination rate. The dose estimate for ^{125}I will decrease by a factor of 2 if the biologic half-time is reduced from 68 days to 21 days. For ^{131}I the dose estimate will decrease by 20% for this same reduction in biologic half-time. For the short-lived radioiodines, variations in biologic half-times have little effect on the absorbed dose.

Since the newborn thyroid dose is derived directly from the adult thyroid dose by Wellman and Anger, the dose to the adult thyroid was calculated for purposes of comparison. The same biologic model (*12*) employed by Wellman and Anger was used. However, updated absorbed fraction (*6*) and radiation emission data (*7*) were utilized. In the case of ^{125}I the present dose estimate is 16% lower than the value calculated by Wellman and Anger (*1*). The dose estimates for the remaining radioiodines agree within 6%. The present adult dose estimates demonstrate no significant differences from those calculated in MIRD Dose Estimate Report 5 (*9*).

The thyroid uptake for the newborn can be as high as 70-80% in the immediate postpartum period. This will result in a higher cumulated activity than employed by Wellman and Anger (*1*). For example, a thyroid uptake of 50% results in a cumulated activity of 7.1 μCi-hr per μCi of ^{123}I administered. This value is approximately two times greater than the cumulated activity used by Wellman and Anger. This difference in the assumed thyroid uptake is primarily responsible for the increase in the dose estimates for the newborn.

Kereiakes et al. (*3*), assuming a thyroid mass of 1.5 g and a thyroid uptake of 70%, reported newborn thyroid doses which were identical to those calculated by Wellman and Anger (*1*), who used a 27% thyroid uptake. Because increased cumulated activities associated with the higher thyroid uptake were not incorporated into the dose determinations, the dose estimates by Kereiakes et al. (*3*) underestimate the dose by a factor of 2–11.

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