Exposure to Technologists from Preparing and Administering Therapeutic ^{131}I: How Frequently Should We Bioassay?

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It is common for nuclear medicine technologists to perform procedures involving the preparation and administration of therapeutic levels of ^{131}I-sodium iodide. This small study looked at the question of how much internal exposure a technologist receives, on average, while preparing and administering a therapeutic dose of ^{131}I. **Methods:** The study estimated technologists' intake of airborne ^{131}I by measuring air concentrations in their breathing zone during therapeutic procedures using ^{131}I capsules. The measurement was made by determining the radioactivity collected on a charcoal filter contained within a personal air sampler. The radioactivity captured by the charcoal filter was assessed in a well counter. **Results:** Given these data, we were able to estimate the average ^{131}I intake of a technologist working in a general nuclear medicine department over a period of 1 y: about 19.2 kBq (0.52 μCi). **Conclusion:** The NRC requirement is to monitor workers who could inhale or ingest more than 185 kBq (5 μCi) of ^{131}I in 1 y. The results of this small study suggest internal exposure rates that are well below the annual Nuclear Regulatory Commission trigger limits for individual bioassay.

Key Words: bioassay; airborne contamination; iodide-131 sodium iodide

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The handling and administration of ^{131}I carries a risk to the technologist due to the natural affinity of the human thyroid for iodine. This affinity of the thyroid for iodine, coupled with the relatively high radiation exposure levels associated with ^{131}I β- and γ-radiation emissions, can pose significant risks to the thyroid gland if radioiodine from a patient dose is incorporated into the technologist's body (*1*). The primary route of incorporation, given the chemical volatility of iodine, is airborne. Because of these risks, the Nuclear Regulatory Commission (NRC) requires regular monitoring of workers who receive more than 10% of the annual limit on intake (ALI) of ^{131}I. The NRC defines ALI as the amount of radioactivity of a given radionuclide inhaled or ingested by a radiation worker in a year that would result in a committed effective dose equivalent of 50 mSv (5 rem) or a committed effective dose equivalent of 500 mSv (50 rem) to an individual organ or tissue. The ALI for ^{131}I is 1.85 MBq (50 μCi). The NRC requirement is to monitor workers who could inhale or ingest more than 0.185 MBq (5 μCi) of ^{131}I in a year. The ALI for ^{131}I is 1.85 MBq (50 μCi). By dividing this ALI limit by the volume of air that a worker inhales in a working year, the limit can be converted to a limit on the average air concentration of the radionuclide of interest. This is called the derived air concentration. The derived air concentration of ^{131}I is 7.7×10^{-4} Bq/mL (2.08×10^{-8} μCi/mL) (*2*).

NRC Regulatory Guide 8.20 suggests that monitoring be performed via quarterly bioassay of workers (*3*). This NRC guideline is written into many facility radioactive material licenses as a requirement.

Technologists often administer ^{131}I doses with a total activity of greater than 3.7 GBq (100 mCi) within a calendar quarter. For this reason, a radioactive material license bioassay requirement can occur for multiple individuals. The NRC Regulatory Guide incorporating this suggestion was first written in 1979. Current ^{131}I solutions and capsules have been reformulated and are less volatile than in previous years. Specifically, ^{131}I capsules have been modified by adding buffers, adding chemical stabilizers, and adjusting pH levels (*4*). Because therapeutic doses of ^{131}I are no longer as volatile as they once were, the risk of internal exposure to a technologist from handling therapeutic radioiodine has been found to be less today than the same dose of ^{131}I solution in 1979 (*5*). It might be reasonable to raise the limits of ^{131}I handled that routinely trigger bioassay (*6*). This change could save technologists with exposures well below the NRC limits the task of frequent bioassay and related paperwork.

This small-scale study addressed the question of how much internal exposure a technologist receives on average while administering a therapeutic dose of ^{131}I in capsule form. A therapeutic dose is defined as a dose having an

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activity of at least 1.22 GBq (33 mCi). By answering this question, one can estimate the average internal exposure received by a technologist in a given year for comparison to NRC exposure limits. One can then take a fresh look at the activity limits requiring bioassay necessary to meet the NRC requirement to monitor workers who could inhale or ingest more than 185 kBq (5 μCi) of ^{131}I in a year.

MATERIALS AND METHODS

The subjects in this study were practicing nuclear medicine technologists within a local metropolitan area. Pregnant workers were outside the scope of the study and were excluded. The nuclear medicine departments that participated in this study regularly perform ^{131}I therapy procedures using ^{131}I capsules. These departments were asked to notify the investigator whenever a ^{131}I therapy procedure involving at least 1.22 GBq (33 mCi) was scheduled. This study measured a total of 7 air samples taken from technologists working in 4 nuclear medicine departments.

The technologists' intake of airborne ^{131}I was estimated by measuring the air concentration of ^{131}I during therapeutic procedures involving activities of at least 1.22 GBq (33 mCi). Air concentrations of ^{131}I were measured using a personal air sampler (model 08-430; Victoreen, Inc.). This air sampler, when turned on, pulls air through a charcoal filter. A 5-digit air volume register gives the units of air pulled through the filter. The technologist performing a procedure wore the personal air sampler either by clipping the air pump to a waist band or by placing the pump in a laboratory coat pocket. The pump was attached to a plastic hose that terminated with an air sampling head. The sampling head was clipped to the technologist's lapel such that it faced downward.

Part of the air sampler is a head housing that contains charcoal filter paper. The filter paper is held in place by a metal grill and open plastic cap. Before a technologist initiated the assay of a ^{131}I dose, the personal air sampler was checked to ensure that a clean charcoal filter paper was present in the head of the air sampler. The 5-digit readout on the air volume register was recorded. When the technologist was ready to access and assay the ^{131}I capsule, the air pump was switched on. If the dose was to be administered immediately, the pump remained running until the patient swallowed the entire dose. If the dose was not administered immediately, the air pump was turned off and was turned back on only when the technologist returned to the hot laboratory to retrieve the dose for administration.

The activity of the ^{131}I dose to be administered was recorded, along with the time at which the dose was assayed. Once dose administration had been completed, the 5-digit readout on the air volume register was again recorded. The difference between the sample numbers before and after administration provides information on the amount of air pulled through the filter, which is then converted to units of milliliters. The efficiency of the air sampler in collecting ^{131}I activity in the air was measured during the first sample collection. For this measurement, a second charcoal filter paper was placed behind the plastic mesh, sandwiching the mesh between the 2 filters. After the procedure, both filters were counted in the well counter, and the efficiency of the air sampler in collecting airborne ^{131}I was calculated to be 23%.

The radioactivity on the charcoal filter was measured using a well counter (Atom Lab 950; Biodex) set to record counts with a window setting of 260–470 keV. A background count was measured for 60 s. The charcoal filter paper was placed in the test tube and counted for 60 s. The net counts per minute were calculated by subtracting the background counts from the filter counts. The net filter counts per minute obtained from the well counter for each sample were further adjusted to allow for the 23% ^{131}I trapping efficiency of the charcoal filter.

The efficiency of the well counter used for this study is 80% for ^{131}I measured with the 260- to 470-keV window. Adjusting the net filter counts per minute for filter efficiency along with well counter efficiency yielded the net disintegrations per minute in each filter. The disintegrations per minute was converted to units of becquerels, and this value was divided by the total volume of air pulled through the pump (mL) to give the ^{131}I air concentration in Bq/mL (Table 1).

RESULTS

From these data, one learns that an average air concentration of 0.0024E−03 kBq/mL (6.4E−05 μCi/mL) of air can be expected from the handling and administration of a dose of 5.74 GBq (155 mCi) of ^{131}I. The NRC assumption for its derived air concentration calculations is that an average worker inhales approximately 20 L of air per minute. A technologist utilizing a full 10 min of ^{131}I handling for a procedure would inhale about 2,000 L of air. One could project a total ingestion for the technologist of 4.81 kBq (0.13 μCi) during such a procedure.

DISCUSSION

Table 2 summarizes the number of procedures and the number of participating technologists at each of the study locations. The average number of ^{131}I procedures performed by each technologist in this study was 4. Therefore, the average ^{131}I dose a technologist in this study received in a year was 4×4.81 kBq (0.13 μCi), or 19.2 kBq (0.52 μCi), well below the NRC monitoring guideline of 185 kBq (5 μCi) per year. The actual dose would probably be lower because this estimate assumes an average dose activity of 5.74 GBq (155 mCi) and a handling time of 10 min per dose.

The data are consistent with another study that retrospectively analyzed 272 bioassay results from technologists who performed ^{131}I procedures (*7*). The low results found in this previous study (near background in most cases) were attributed to the technologist's use of certain radiation safety precautions such as wearing gloves, limiting time spent near the ^{131}I dose before administration, and using tongs to handle the dose.

TABLE 1
Airborne Concentration of ^{131}I During Handling and Administration of ^{131}I Capsules

Sample no.	Clinical site	Assayed ^{131}I capsules (GBq)	Charcoal filter ^{131}I activity (Bq)	Air volume sampled (mL)	^{131}I air concentration (Bq/mL)
1	A	4.94	7.77	115,453.0	7.4E−05
2	B	6.22	1.37	16,744.3	7.4E−05
3	A	3.86	5.92	98,192.0	7.4E−05
4	C	6.02	74.0	25,529.9	2.89E−03
5	C	9.44	555.0	52,610.0	1.07E−02
6	D	3.70	23.3	28,320.0	8.14E−04
7	C	6.04	59.2	27,804.0	2.5E−03
Average		5.75	103.8	52,093.3	2.4E−03

This small-scale study's results indicate a typical annual intake that is well below the level that the NRC advises as a trigger level for bioassay monitoring. The study results indicate that one would have to administer close to 222 GBq (6,000 mCi) of ^{131}I in 1 y to reach the NRC trigger limit for bioassay.

It is common for nuclear medicine departments to bioassay technologists several times each year, often more frequently. Departments commonly bioassay personnel on a fixed schedule that is independent of procedures performed. Given the low exposure rates, it might be worthwhile for departments to reevaluate their bioassay programs to save time and expense while continuing to ensure compliance.

Several factors limit the generalizability of the study results. A major limitation is the small sample size. Larger sample numbers using subjects from a wide variety of clinical sites would provide more reliable statistics. A significant variable in this study was the behavior of each technologist during a given procedure. Such variables include the length of time the technologist is exposed to ^{131}I, the technologist's proximity to the dose before administration, and the activity of the dose. It is likely that these factors contributed to the wide variation from sample to sample and from site to site in number of procedures performed and ^{131}I air concentrations of each sample.

Another limitation is the type of samples used. All samples collected in this study were ^{131}I capsules, but that is not the only form of ^{131}I that technologists handle. Some clinics use liquid ^{131}I-labeled tositumomab for treatment of non-Hodgkin lymphoma or ^{131}I in the form of ^{131}I-meta-iodobenzylguanidine.

TABLE 2
Clinical Procedures Performed Involving ≥1.22-GBq (33 mCi) ^{131}I Capsules in 1 Year

Clinical site	No. of procedures in last year	No. of participating technologists
A	12	4
B	4	3
C	29	5
D	14	4
Average	15	4

CONCLUSION

This small study showed an average ^{131}I inhalation intake of 4.81 kBq (0.13 μCi) during administration of 5.74 GBq (155 mCi) of ^{131}I in capsule form. This value allows for a full 10 min to handle, assay, and administer the dose. On the basis of this small-scale study, a technologist would have to administer approximately 18.5 GBq (500 mCi) of ^{131}I every month to trigger the NRC threshold of 10% of the ALI for ^{131}I. This is the trigger level the NRC recommends for bioassay of occupational workers.

One can say that the risk of internal exposure is less today than previously because of increased stability of therapeutic capsule formulations of ^{131}I and widespread adoption of the capsular form of ^{131}I for therapy. Today, ^{131}I bioassay recommendations written by the NRC in 1979 still guide many nuclear medicine department bioassay programs. In light of the low risk to technologists, many departments could continue to conform to the guidelines while significantly reducing the frequency of ^{131}I bioassay. The time and administrative burden saved could be put to use in areas of patient care or to address more pressing radiation safety concerns.

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REFERENCES

1. Ziessman HA, O'Malley JP, Thrall JH. *Nuclear Medicine: The Requisites in Radiology.* 3rd ed. Philadelphia, PA: Mosby; 2006:215–254.
2. U.S. Nuclear Regulatory Commission. *Standards for Protection Against Radiation*. Washington, DC: U.S. Government Printing Office; 2006. 10 CFR part 20.
3. U.S. Nuclear Regulatory Commission. *Applications of Bioassay for I-125 and I-131*. Washington, D.C: U.S. Government Printing Office; 1979. Regulatory Guide 8.20.
4. Luckett LW, Stotler RE. Radioiodine volatilization from reformulated sodium iodide I-131 oral solution. *J Nucl Med.* 1980;21:477–479.
5. Nishiyama H, Lukes SJ, et al. Internal contamination of laboratory personnel by ^{131}I. *Radiology.* 1980;137:767–771.
6. Liang Y, Chu RY, Galbraith WK, Macdurmon GW, Sonnad JR. Establishing a threshold for I-131 bioassay in nuclear medicine personnel. *Health Phys.* 2008;95 (5, suppl)S175–S179.
7. Bjorklund A, Phegley D, Smith R, Petti M, Robichaux J. The thyroid burden in personnel who administer therapeutic dosages of I-131 is preventable [abstract]. *J Nucl Med.* 2006;47(suppl):539P.