Measurement of Iodine-123 Thyroid Uptake Using a Gamma Camera with LEAP Collimator

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Objective: This study compared the ^{123}I thyroid uptake measurements obtained from a gamma camera fitted with a low-energy all-purpose (LEAP) collimator to those obtained from a thyroid uptake probe and gamma camera fitted with a pinhole (PH) collimator.

Methods: Thirty-one patients (27 female and 4 male patients) were studied for comparison between a probe and a gamma camera fitted with LEAP collimators. A different group of 25 patients (20 female and 5 male patients) were studied for comparison between LEAP and PH collimators. The patients were given 7.4–11 MBq (200–300 µCi) ^{123}I capsules orally. Uptake with both the probe and the gamma camera was measured at 5 h and 24 h. The uptake measurements by these 3 methods were compared.

Results: Comparison of all the camera uptake values with the probe system correlated well with correlation coefficient values ranging from 0.912–0.988. The probe system yielded uptake ratios slightly higher than those measured by the gamma camera with LEAP collimator. Comparison between LEAP and PH uptake values resulted in a correlation coefficient of 0.979 for 5 h and 0.931 for 24 h uptake.

Conclusion: Iodine-123 uptake with a gamma camera fitted with a LEAP collimator can accurately and consistantly be used to determine the thyroid uptake of ^{123}I if proper ROIs are applied.

Key Words: iodine-123; thyroid uptake measurement

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Radioactive ^{123}I has been described as theoretically the best tracer for thyroid imaging because it is physiologic, has excellent physical characteristics ideal for gamma camera imaging, and delivers a low radiation dose to the patient. Iodine-123 is the recommended tracer for diagnostic thyroid studies because of these advantages (*1*,*2*). These same characteristics combine to contribute to a systemic dead time for the probe method. Lee et al. (*3*) have found the probe system yielded uptake ratios higher than expected values. The thyroid uptake ratios as measured by the probe were 1.3 times greater than the corresponding ratios measured by gamma camera fitted with a pinhole (PH) collimator whose count response was shown to be linear throughout the values tested (*3*). Maintaining distance between the patient/standard is critical with the PH collimator. Procedure guidelines recommend the use of a scintillation camera with a LEAP collimator and appropriate ROIs (*4*). We performed this analysis to evaluate the uptake measurements from a gamma camera fitted with a low-energy all-purpose (LEAP) collimator in comparison with both the measurements from a probe and a gamma camera fitted with PH collimators.

MATERIALS AND METHODS

Thirty-one patients (27 female and 4 male patients) were studied for comparison of thyroid uptake ratios measured with a thyroid uptake probe (Ludlum model 261; Atomic Products Corp., New York, NY) and a gamma camera (GE Starcam 300A mobile camera; General Electric, Milwaukee, WI) fitted with a LEAP collimator. A different group of 25 patients (20 female and 5 male patients) were studied for comparison of thyroid uptake ratios measured with both a LEAP and a PH collimator. The ^{123}I used in this study was obtained locally, produced by the $\{^{124}Te(p,2n)^{123}I\}$ method, with $< 5\%$ ^{123}I at the time of calibration. Each patient was given a 7.4–11 MBq (200–300 µCi) ^{123}I capsule orally. Uptake was measured with the probe and the gamma camera at 5 h and 24 h. The thyroid and phantom were measured from a distance of 20 cm with the probe. Uptake measured with the gamma camera was calculated with and without ROIs over the thyroid, the capsule and with various background ROIs.

A 10-cm distance was maintained with both LEAP and PH (5-mm aperture) collimators. The distance of 10 cm was chosen because it was suitable for all patients, especially women with large breasts. Two-minute counts were acquired over the thyroid, the thigh and the phantom. A zoom factor of 2 was used for thyroid, thigh and capsule (standard) with the LEAP collimator. No zoom factor was used with the PH collimator. Count variation with distance for both LEAP and PH collimators was obtained (Fig. 1). The LEAP response with varying

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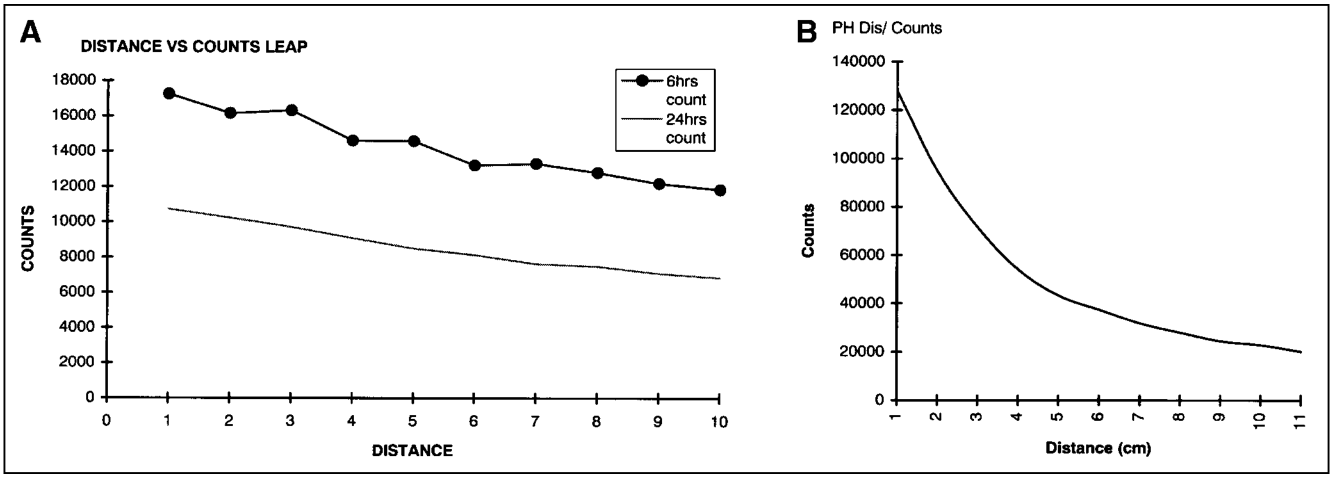

FIGURE 1. The count variation with distance is (A) small with the low-energy all-purpose (LEAP) collimator and (B) large with the pinhole (PH) collimator.

counting rates also was obtained (Fig. 2). The uptake was calculated without applying any ROIs.

RESULTS

Table 1 shows the results of the comparison between the probe and various analysis methods for measurements made with the gamma camera with a LEAP collimator (Figs. 3, 4). Methods B and C yielded lower uptake values. All other methods gave similar values. All the camera uptake values in comparison with the probe system values correlated well with a correlation coefficient (r) value ranging from 0.912–0.988. The clinical data summarized in Table 2 show that the probe system yielded uptake ratios slightly higher than those measured by the gamma camera with a LEAP collimator.

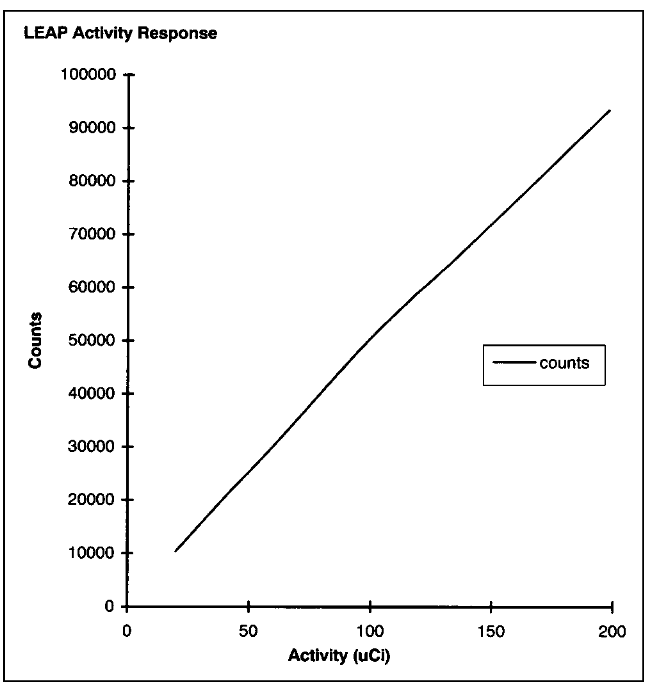

FIGURE 2. Linear response of the low-energy all-purpose (LEAP) collimator with increasing activity.

The clinical data summarized in Table 3 and plotted in Figure 5 show the comparison between LEAP and PH collimator uptake values with r = 0.979 at 5 h and 0.931 at 24 h. The regression line in Figure 5 shows that the 5-h uptake ratios, as measured by the LEAP, were related to the PH measurements by the regression equation:

$Y = 1.0791x - 1.48$
y = LEAP uptake ratio
x = PH uptake ratio.

The 24-h uptake regression analysis yielded similar results (Fig. 5B). The regression line was calculated as:

$Y = 0.085x + 4.57$
y = LEAP uptake ratio
x = PH uptake ratio.

DISCUSSION

The count response of the gamma camera with both the LEAP and PH collimators was linear throughout the ranges tested. Lee et al. (*3*) have shown that the count response of the probe varied directly with the sample activity. The probe

TABLE 1
Mean Thyroid Uptake Values and Standard Deviations for Probe and Various Analysis Methods of Gamma Camera Measurements (n = 31)

Method	5-h uptake Mean SD	Regression equation Y	24-h uptake Mean SD	Regression equation Y
Probe	57.7 ± 29	—	61 ± 28	—
Method A	56 ± 30	4.4 + 0.95X	57 ± 27	5.2 + 1.0X
Method B	30 ± 17	7.8 + 1.65X	22 ± 11	9.0 + 2.3X
Method C	44 ± 24	5.7 + 1.20X	39 ± 18	4.4 + 1.4X
Method D	55 ± 30	5.1 + 0.95X	56 ± 26	2.8 + 1.0X
Method E	55 ± 29	4.5 + 0.95X	57 ± 26	2.9 + 1.0X
Method F	54 ± 30	6.1 + 0.95X	56 ± 26	4.1 + 1.0X

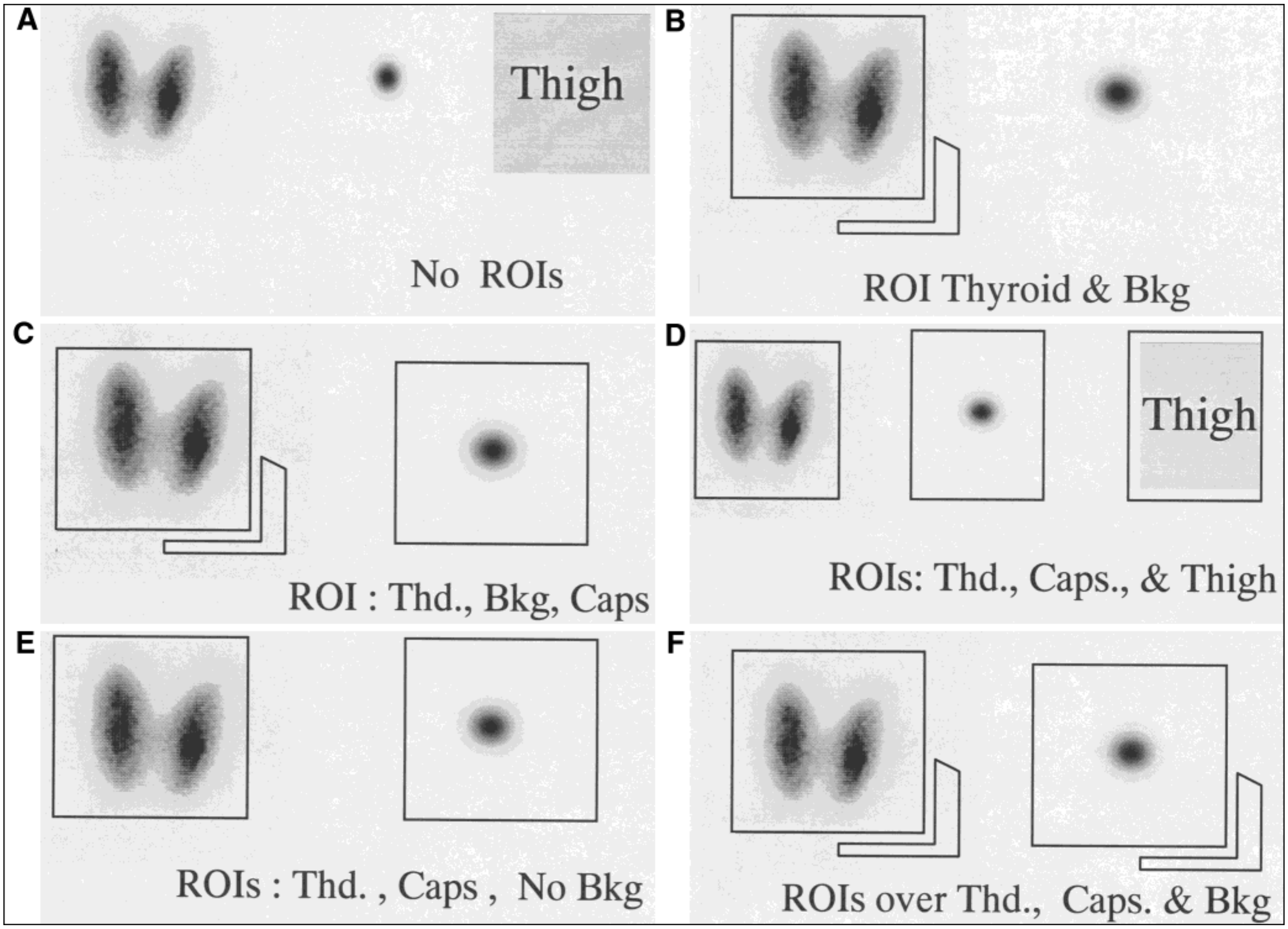

FIGURE 3. Different analysis methods used to compare probe uptake with low-energy all-purpose (LEAP) collimator uptake in 31 patients: (A) no ROIs were used; (B) both thyroid and neck background ROIs were used; (C) thyroid, neck background and standard (capsule) ROIs were used; (D) thyroid, standard and thigh background ROIs were used; (E) only thyroid and standard ROIs were used; and (F) thyroid, neck background, standard and standard background ROIs were used.

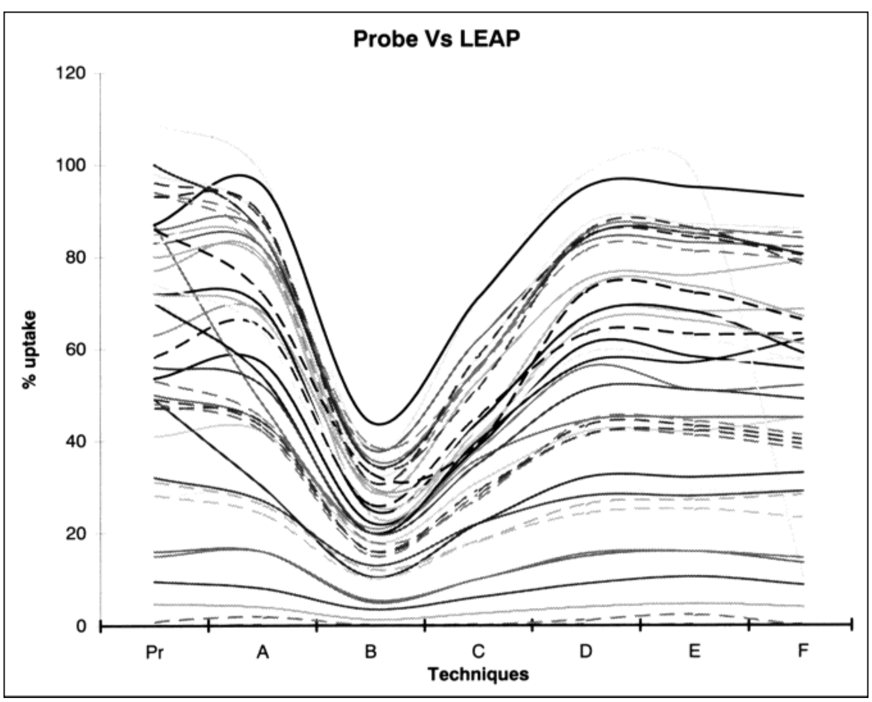

FIGURE 4. Comparison of uptake values measured with a probe and low-energy all-purpose (LEAP) collimator using methods A through F, as described in Figure 3.

TABLE 2
Radioactive Iodine Uptake Ratios of 31 Patients Obtained with a Probe and a Gamma Camera with LEAP Collimator (Method A)

Diagnosis	Number of patients	5-h uptake		24-h uptake	
		Probe	LEAP	Probe	LEAP
Euthyroid	4	16.5 ± 4.5	15.8 ± 4.6	35 ± 9.5	28.7 ± 1.7
Hyperthyroid	23	64 ± 24	62 ± 25.7	74 ± 18.5	69.5 ± 18.0
Hypothyroid	4	3.7 ± 2	3.5 ± 1.7	10.7 ± 9.8	10.2 ± 8.6

TABLE 3
Radioactive Iodine Uptake Ratios of 25 Patients Obtained with Both the LEAP and the Pinhole Collimator

Diagnosis	Number of patients	5-h uptake		24-h uptake	
		LEAP	Pinhole	LEAP	Pinhole
Euthyroid	10	19.2 ± 5.2	18.3 ± 5.2	27.7 ± 6	25.7 ± 5
Hyperthyroid	11	66.3 ± 23	70 ± 26.3	68 ± 13.2	62.3 ± 10
Hypothyroid	4	6.3 ± 1.3	4 ± 0.66	8.2 ± 4.1	7.5 ± 5

overestimates the thyroid uptake (*3*). The various LEAP methods with and without ROIs correlated well with the probe measurements. Methods B and C yielded lower uptake values. The probe estimation was 1.6 and 1.2 times greater for 6-h uptake and 2.3 and 1.5 times greater for 24-h uptake for Methods B and C, respectively. Inclusion of background and scatter counts in the standard count measurement resulted in lower uptake measurements with the gamma camera. It has been reported that dead-time error is insignificant when an equal activity standard is counted at the time of the uptake measurement (*5*). The majority of our patients (74%) were hyperthyroid with a high uptake measured by both the probe and the LEAP collimator, which could be the reason for less error and good correlation between the 2 methods. Maguire et al. (*6*) have reported that, depending on the uptake, the patient and standard counting rates would be comparable and subject to approximately equivalent dead-time losses. The error would partially cancel out when one count is divided by the other (*6*).

The correlation between LEAP (Method A) and PH collimators was high, demonstrating that LEAP can be used for ^{123}I thyroid uptake measurements. Slight variation in distance with

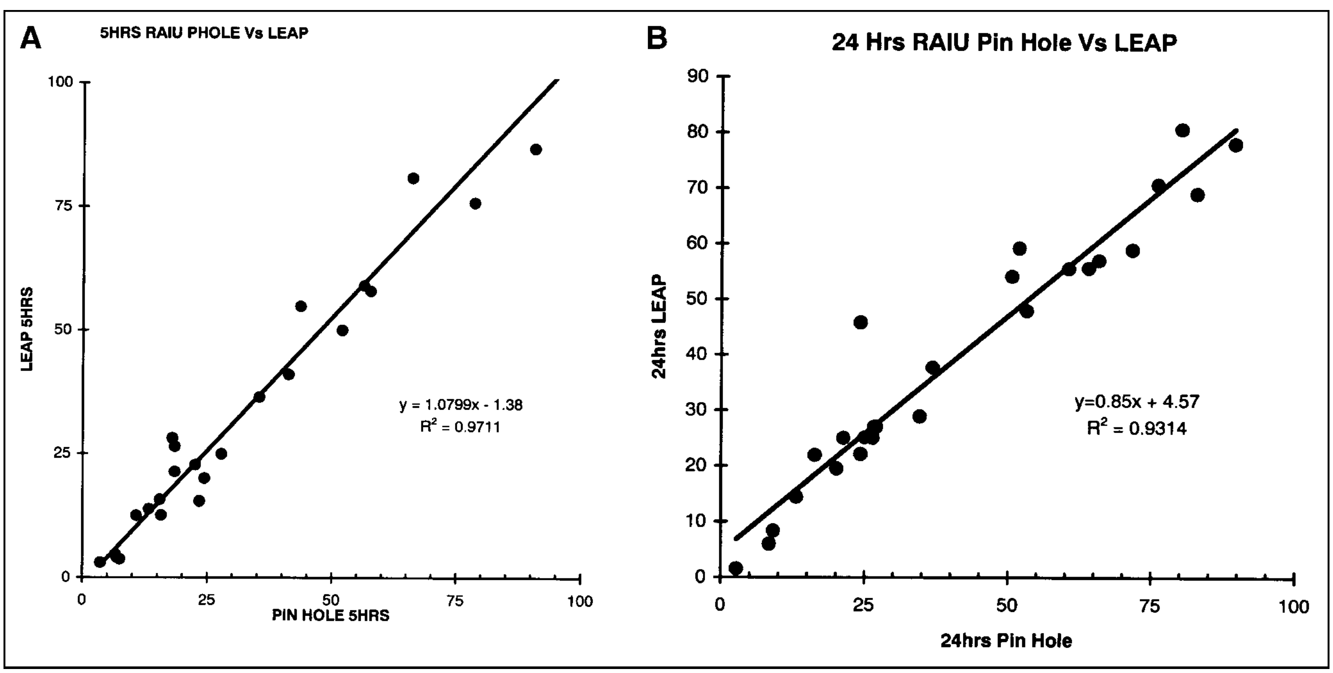

FIGURE 5. At both (A) 5 h and (B) 24 h the low-energy all-purpose (LEAP) collimator uptake ratios correlated well with the pinhole collimator (PH) ratios.

PH causes erroneous uptake values (Fig. 1B) and technologists must be consistent in maintaining the distance while measuring the patient and the standard. The use of LEAP avoids these errors because the count response is linear and small variations in the distance do not affect the uptake values. The procedure guidelines state that proper ROIs must be drawn to obtain consistent results (*4*).

CONCLUSION

Iodine-123 uptake measured with a gamma camera fitted with a LEAP collimator can yield accurate and consistent results if proper ROIs are applied. One limitation of this study is that we could not compare the probe and the PH because our probe was discarded.

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