

Effect of Technetium-99m on Iodine-131 Thyroid Uptake Measurements

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Following administration of 2.5–5.0 mCi [^{99m}Tc]pertechnetate, several hundred microcuries may be present in the necks of hyperthyroid patients after 6 hr. Coincidence summing of Tc-99m photons may disturb I-131 uptake measurements in such patients if an oral diagnostic dose of I-131 is administered immediately after completion of a [^{99m}Tc]pertechnetate scintigram. Using a lower discriminator level of 300 keV, false increases of 10%–50% may occur at 6 hr. The 24-hr uptake is also affected if an I-131 predose measurement is performed after administration of the Tc-99m dose. The authors have shown that these errors may be prevented by using a 1-mm lead filter in front of the scintillation detector. The attenuation of Tc-99m photons by the filter effectively eliminates summation pulses while it reduces the I-131 countrate by approximately 28%.

Technetium-99m pertechnetate or I-123 has virtually replaced I-131 as the radiopharmaceutical for routine thyroid imaging. However, the I-131 radioiodine uptake test is still a useful test for confirming the diagnosis of hyperthyroidism and for estimating the optimal therapeutic dose of I-131 in the treatment of hyperthyroidism. Erroneously high (more than 100%) iodine uptake values may be calculated if patients had Tc-99m thyroid scintigraphy earlier the same day. The authors decided to investigate possible causes of this phenomenon, as well as measures to reduce this effect by using a lead filter.

If oral I-131 is administered immediately after completion of the [^{99m}Tc]pertechnetate scintigram, the 6-hr I-131 uptake may appear to be falsely high if the thyroidal uptake of [^{99m}Tc]pertechnetate is excessive. Disturbance of the I-131 counts may be attributed to the fact that I-131 activities of about 1–5 μ Ci (37–185 kBq) must be measured in the presence of several hundred microcuries of Tc-99m with the result that breakthrough of a small percentage of Tc-99m counts into the I-131 window would affect the I-131 counts considerably. Using published measurements (1,2) of [^{99m}Tc]pertechnetate retention, the activities present in the thyroids of patients with high, 20-min uptakes after administration of 2.5 and 5 mCi (92.5 and 185 mBq) [^{99m}Tc] pertechnetate may be estimated as in Table 1.

It is known that a high photon flux may distort gamma ray spectra due to coincidence summing in scintillation detectors and may lead to "ghost images" appearing in gamma camera scintigrams (3). In order to quantitatively evaluate the influ-

ence of Tc-99m retention on I-131 uptake measurements, two other effects also have to be considered: (a) Due to the presence of large amounts of Tc-99m, deadtime may cause a depression of I-131 counts which may compensate for additional Tc-99m counts appearing in the I-131 window. Therefore, the effect on I-131 counts if 100–500 μ Ci Tc-99m is present would have to be measured; (b) It has been reported (4) that extended exposure of some scintillation detectors to radiation may cause a gradual peak-shift. If such an effect is present it might have a time-dependent effect on measurements.

MATERIALS AND METHODS

A scintillation detector* connected to a dual channel spectrometer/scaler[†] was used. The detector had a 2"×2" NaI(Tl) crystal and was fitted with an International Atomic Energy Agency (IAEA) thyroid uptake collimator. Measurements were performed with I-131 and Tc-99m sources placed at a working distance of 25 cm in a lucite phantom constructed according to IAEA specifications.

In order to examine the effect of deadtime, eight different aliquots of a Tc-99m solution were weighed and counted in 120–180 keV and 120–450 keV windows (Fig. 1). Similar samples were also counted in a 240–320 keV window in order to examine whether the Tc-99m counts appearing in the iodine window were proportional to the activity (Figs. 1, 2). To test for a Tc-99m summation peak (280 keV), Tc-99m spectra between 190 and 330 keV were also determined on these samples

TABLE 1. Estimated Tc-99m Activity (μ Ci) in Neck Administration of 2.5 and 5 mCi Pertechnetate

Dose (mCi)	% Uptake (20 min)	Time After Administration		
		20 min (I-131 Predose Measurement)	6 hr*	24 hr
2.5	10	250	40–100	4
	25	625	100–260	10
	50	1,250	200–520	20
5.0	10	500	80–200	8
	25	1,250	200–520	20
	50	2,500	400–1,040	40

*Higher values estimated from Ref. 1, lower values from Ref. 2.

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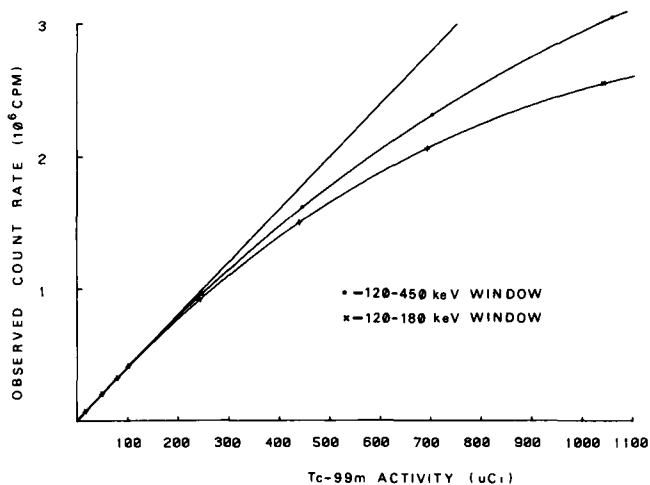


FIG. 1. Effect of deadtime. Curves of observed count rate vs. activity of Tc-99m source at a working-distance of 25 cm. Spectrometer windows: 120–180 keV and 120–450 keV. The straight line is the regression line of the six points with lowest activity, indicating expected counts with negligible deadtime.

when their activities were 943, 633, 423, and 270 μCi , respectively (Fig. 3).

To test for any peak-shift, an I-131 spectrum was determined using a 14 μCi I-131 capsule and employing a 20 keV window moved in 20 keV increments. The spectrum was then repeatedly measured every 15 min for 2 hr in the presence of an initial activity of 280 μCi of Tc-99m placed at the same distance. No significant peak-shift could be detected in this way.

The effect that the presence of Tc-99m has on the counts measured in various I-131 windows was measured as follows: Tc-99m sources of 100, 250, and 500 μCi in glass vials and 9 μCi and 12.4 μCi I-131 capsules in test tubes were used. Each Tc-99m source was successively placed side-by-side with the test tube containing the I-131 capsule in the IAEA phantom at 25-cm working distance. The sources were held in position by means of adhesive plastic. One-minute counts of both

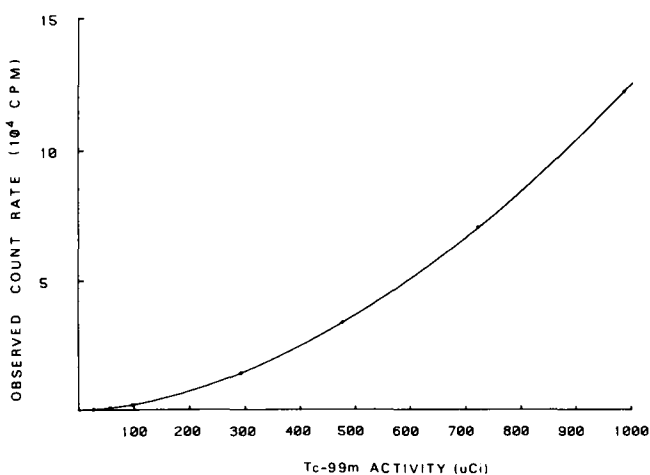


FIG. 2. Curve of observed count rate vs. activity of Tc-99m source at working-distance of 25 cm. Spectrometer window: 240–320 keV.

sources together in 10 windows varying from 330–450 keV to 240–450 keV were obtained. The Tc-99m source was then carefully removed without changing the position of the I-131 capsule, and the measurements were repeated. Thus only about 10 min elapsed between the measurements of the I-131 activity in each window with and without Tc-99m. During this time, the Tc-99m activity changed by only 2%.

The measurements were then repeated after placing a 1-mm thick lead filter in front of the detector. This attenuated the Tc-99m photons to approximately 7% while the I-131 photons were attenuated to 73% of the count rate without filter.

Background was determined for each counting condition and subtracted. The differences between the I-131 counts obtained with and without the presence of Tc-99m in each window were determined for measurements made with and without the 1-mm lead filter.

RESULTS

Measurements Without Lead Filter

The differences between those I-131 counts obtained in 1 min with Tc-99m being present and those without it were calculated for each window. They were found to be significant by the Wilcoxon rank sum test ($p < 0.01$ for 500 and 250 μCi Tc-99m and $p < 0.02$ for 100 μCi Tc-99m). To estimate the effect that these differences would have on actual iodine uptake

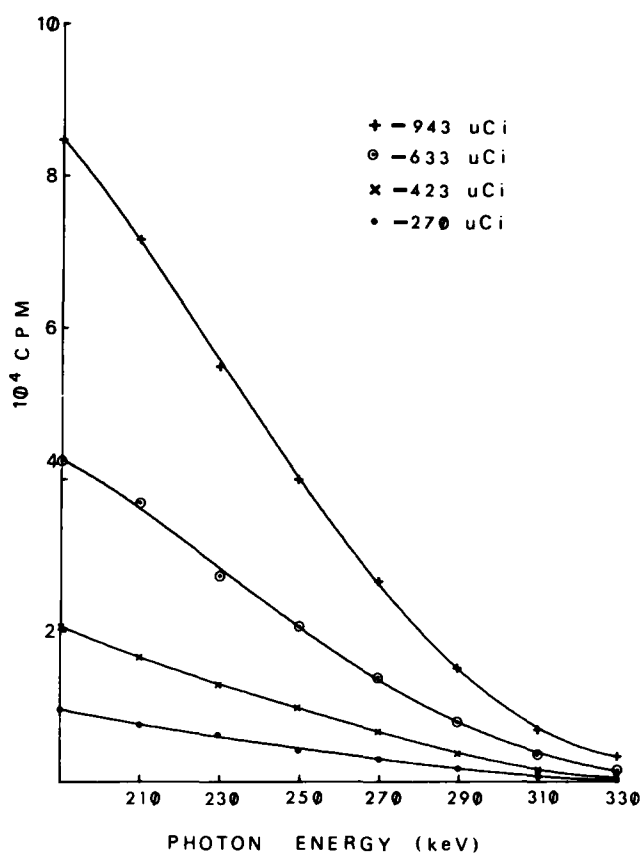


FIG. 3. Spectra between 190 and 330 keV obtained with different activities of Tc-99m.

measurements, the measured I-131 counts (from 9 and 12.4 μCi sources) obtained without Tc-99m were normalized to those expected from a 5 μCi I-131 source. These effects varied from 11,014 cpm for the 330–450 keV window to 14,692 cpm for the 240–450 keV window. The above differences were then

expressed as percentages of the appropriate 5 μCi I-131 count, which indicated the amount by which the I-131 uptake percentage would apparently be raised by the presence of technetium. These percentages are depicted graphically in figure 4.

Measurements with a 1-mm Lead Filter

Table 2 shows the 1-min I-131 counts normalized to 5 μCi activity measured with and without the 1-mm lead filter as well as the differences between I-131 counts obtained with and without various amounts of Tc-99m present, using the lead filter. In applying the Wilcoxon rank sum test, these differences were not found to be significant ($p > 0.1$).

DISCUSSION

Figure 1 shows that a lowering in count rate of the order of 5% may be expected in the presence of 250 μCi of Tc-99m.

The IAEA recommendations for thyroid uptake measurements state that the contribution from scattered radiation should be reduced to a minimum, but they do not recommend any specific lower discriminator level. It has, however, been suggested that a lower discriminator level of about 300 keV be used (5). This value is usually also close to the maximum that may be used in view of ensuring minimal change in count rate with drift of the spectrum. Figure 4 shows that when this discriminator level is used, the I-131 percentage uptake may be falsely raised by about 10% if 250 μCi Tc-99m is present in the neck. If 500 μCi Tc-99m is present, the error may increase to 53%. This error may occur (Table 1) if a scintigraphy dose of 5 mCi of [$^{99\text{m}}\text{Tc}$]pertechnetate is used and the uptake of technetium is 50%, as may happen in some hyperthyroid patients. If lower discriminator levels below 300 keV are used, the error increases correspondingly. However, if a 1-mm lead filter is placed in front of the detector, the Tc-99m contribution is negligible (Table 2). If an I-131 predose mea-

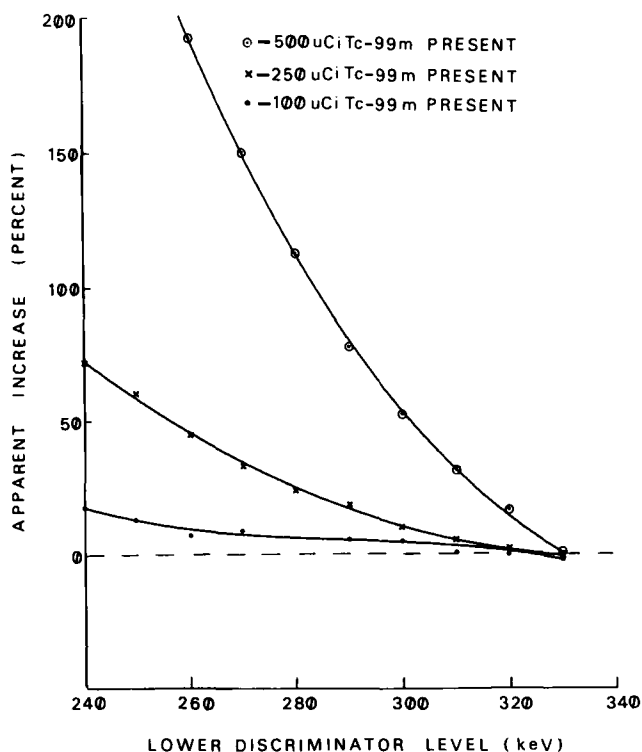


FIG. 4. Apparent increase in percentage of iodine uptake caused by the presence of various amounts of Tc-99m in the neck when a 5 μCi I-131 dose is used. Upper discriminator level was kept constant at 450 keV. Different lower discriminator levels were used as indicated. Standard errors varied between 1.9% and 2.3%.

TABLE 2. Measurements Obtained Using a 1-mm Lead Filter and an I-131 Source*

Energy Window (keV)	Counts from I-131 Alone Without Filter	Counts from I-131 Alone	With Lead Filter		
			(Counts With Tc-99m) Minus (Counts Without Tc-99m)		
			500 μCi Tc-99m	250 μCi Tc-99m	100 μCi Tc-99m
330–450	11,014	7,941	2	-10	-15
320–450	11,580	8,401	27	6	132
310–450	12,168	8,774	-13	84	
300–450	12,366	9,168	44	41	-128
290–450	12,916	9,446	143	-118	
280–450	13,442	9,723	-52	96	38
270–450	13,778	9,969	1	24	
260–450	14,366	10,216	88	157	106
250–450	14,480	10,393	35	-44	
240–450	14,692	10,559	227	76	54

*Normalized to 5 μCi .

surement is performed shortly after administration of pertechnetate, this may also be falsely raised in hyperthyroid patients. The effect would be to falsely lower the uptake measured at 24 hr if this value is subtracted as background, because negligible amounts of Tc-99m would be left by this time (Table 1).

The use of a 1-mm lead filter reduces the I-131 count by approximately 28% (Table 2). This counter changes the standard error in the uptake measurement due to counting statistics from 2.8% to 3.5% when 15% of the dose is present in the thyroid and counting times of 1 min are used.

If the increase in counts in the I-131 window was only due to the tail of the Tc-99m peak appearing in this window, one would expect the Tc-99m contribution to be proportional to the Tc-99m activity. Because there is a nonlinear relationship between Tc-99m counts in the 240–320 keV window and Tc-99m activity (Fig. 2), it may be concluded that the effect is in large part due to summation of Tc-99m pulses, although a summation peak could not be observed (Fig. 3).

CONCLUSION

A significant error may occur in the 6 hr I-131 uptake measurement if I-131 is given immediately after a Tc-99m imaging dose, or if a Tc-99m scintigram (even of another organ) is per-

formed before or during the I-131 study. Its magnitude depends on the lower discriminator level used, and increases as the level is decreased. The error may be eliminated by performing such measurements with a 1-mm lead filter in front of the detector.

FOOTNOTES

*Hewlett Packard Co., Waltham, MA.

†Tri-carb 3002 spectrometer, Hewlett Packard Co., Waltham, MA.

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