Comparison of $^{99m}$Tc and $^{131}$I Scans in Thyroid Function Studies

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SUMMARY
Thyroid function was studied in 170 patients, using technetium-99m ($^{99m}$Tc) and oral radio-iodine ($^{131}$I); 110 patients had normal thyroid function, and 60 had hyperthyroidism. The 20-minute $^{99m}$Tc uptake gave an accurate assessment of thyroid function in 95% of patients, and the 24-hour $^{131}$I uptake was accurate in 92%. One hundred $^{99m}$Tc and $^{131}$I scintiscans were compared by 3 observers. Scans obtained with each isotope were of comparable quality, and in only 1 patient were both scans of poor quality. $^{99m}$Tc is as good as $^{131}$I for assessing thyroid function and morphology, but has several advantages over $^{131}$I.


Technetium-99m ($^{99m}$Tc) in the form of the pertechnetate ion is concentrated in the thyroid gland in the same way as iodide, but does not usually become organically bound. The uptake of $^{99m}$Tc by the thyroid gland reflects the activity of the 'iodide trap' and can be used as an index of thyroid activity. There are several advantages of $^{99m}$Tc over oral radio-iodine ($^{131}$I): the radiation exposure is less; thyroid uptake tests and scans can be done rapidly with considerable saving of time to both patients and laboratory; and $^{99m}$Tc is readily obtainable and cheap, and if it is being used for other scanning procedures its cost is negligible.

The quality of thyroid scans and the accuracy of 20-minute $^{99m}$Tc and 24-hour $^{131}$I thyroid uptake tests in the evaluation of thyroid function were compared at the Thyroid Clinic, Johannesburg General Hospital.

PATIENTS AND METHODS
One hundred and seventy patients attending the Thyroid Clinic for routine diagnostic procedures had 20-minute $^{99m}$Tc and 24-hour $^{131}$I uptake tests and scans performed on successive days. The patients were referred for investigation of thyroid function and morphology and the majority had palpable goitres. Thyroid functional status was evaluated clinically by measurements of total serum thyroxine, by the T$_3$ resin uptake test, and by the calculation of the free thyroxine index and the 24-hour $^{131}$I uptake test. Sixty patients were found to have hyperthyroidism.

Twenty minutes after the injection of 0,5 - 1,0 mCi of $^{99m}$Tc, the neck uptake (NU 20) was measured with an Elscint Scintillation counter. The 20-minute thyroid uptake of $^{99m}$Tc was calculated according to the method of Shimmns et al. which assumes that the extrathyroidal uptake at 20 minutes is 5,46% of total body extrathyroidal uptake. Thus:

$$\text{thyroid uptake of }^{99m}\text{Tc} = \frac{\text{NU 20} - 5,46}{0,945} \% \text{ dose}$$

administered.

The results of 24-hour $^{131}$I uptake tests were calculated after the oral administration of 50 $\mu$Ci $^{131}$I; this high dose was chosen to obtain adequate scans.

Thyroid scans were carried out 40 - 60 minutes after the $^{99m}$Tc injection, and 24 hours after oral $^{131}$I, using a 13-cm Siemens rectilinear scanner. A fine-focus collimator with 667 holes and a sensitivity of 12 000 impulses/cm$^2$/quantum was used for the $^{99m}$Tc scans, and a fine-focus collimator with 163 holes and a sensitivity of 3 600 impulses/cm$^2$/quantum was used for the $^{131}$I scans. The quality of 100 pairs of scans was compared by 3 independent observers; scans were scored from 0 (unreadable) to 2 (good diagnostic quality). The clinical findings on examination of the thyroid gland were available to each observer.

RESULTS
One hundred and seventy pairs of uptake tests were recorded. In the 110 patients with normal thyroid function, the mean 20-minute $^{99m}$Tc uptake was 3,6 ± 2,2% (± SD) and the mean 24-hour $^{131}$I uptake was 30,9 ± 11,3%. In the 60 thyrotoxic patients, the mean 20-minute uptake was 26,4 ± 17,6% and the mean 24-hour uptake was 77,2 ± 14,5%. If a 20-minute uptake of 8,0% (mean ± 2 SD of normal patients) was taken as the upper limit of normal, $^{99m}$Tc gave an accurate assessment of thyroid function in 95% of all patients. Similarly, if a 24-hour uptake of 53,5% (mean ± 2 SD of normal patients) was used as the upper limit of normal, $^{131}$I was accurate in 92% of all patients. For the diagnosis of thyroxicosis, both $^{99m}$Tc and $^{131}$I were accurate in 92% of cases.

One hundred pairs of consecutive $^{99m}$Tc and $^{131}$I scans were evaluated, and the scores of the 3 observers were averaged. The average number of scans in each scoring group is shown in Table I. Radio-iodine scans were marginally better than $^{99m}$Tc scans, but the differences were not statistically significant ($\chi^2$ test). With both isotopes most scans were of good diagnostic quality. Technetium scans were of poor quality when there was
excessive radioactive background, while radio-iodine scans were unobtainable if the $^{131}$I uptake was very low. In only 1 patient were both the $^{99m}$Tc and $^{131}$I scans of poor quality. Typical $^{131}$I and $^{99m}$Tc scans are shown in Fig. 1.

**TABLE I. AVERAGE NUMBER OF SCANS RATED 2 (GOOD), 1 (POOR), OR 0 (UNREADABLE) BY 3 INDEPENDENT OBSERVERS**

<table>
<thead>
<tr>
<th>Score</th>
<th>$^{99m}$Tc</th>
<th>$^{131}$I</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>86.2</td>
<td>89.1</td>
</tr>
<tr>
<td>1</td>
<td>9.7</td>
<td>6.6</td>
</tr>
<tr>
<td>0</td>
<td>4.1</td>
<td>4.3</td>
</tr>
</tbody>
</table>

**Fig. 1. Pairs of $^{99m}$Tc and $^{131}$I scans from the same patients.**

A — normal; B — Graves’s disease; C — ‘cold’ nodule; and D — ‘toxic nodular goitre’ (Tc = $^{99m}$Tc; I = $^{131}$I).

**DISCUSSION**

The use of $^{99m}$Tc in the investigation of thyroid function and morphology is now widely recognized.$^{1-3}$ The mean 20-minute $^{99m}$Tc uptake of 3.35% in our patients with normal thyroid function is comparable to that reported by Shimmins et al.,$^5$ but somewhat higher in other series.$^3,5,7$ The mean 20-minute $^{99m}$Tc uptake in our thyrotoxic group was greater than that reported by others. Both high values could be accounted for by the relative iodine deficiency of the local water (about 20 $\mu$g/l) (Rand Water Board — personal communication).

There was no difference in accuracy of $^{131}$I and $^{99m}$Tc in the evaluation of the thyroid functional status in our patients in discriminating between euthyroid and hyperthyroid states.$^4$

Similar numbers of $^{99m}$Tc and $^{131}$I scans were of good or poor diagnostic quality; in most cases, both scans were of good quality. $^{99m}$Tc scans appeared to be marginally superior to iodine scans in patients with very low 24-hour $^{131}$I uptakes. In only 1 patient were both types of scans of poor quality, suggesting that, if one method gives an inadequate scan, use of the other isotope will frequently be of value. It has been reported that very occasionally a thyroid carcinoma or adenoma will be ‘cold’ on a $^{131}$I scan but functioning on a $^{99m}$Tc scan.$^{10,11}$ In only 1 patient of our series (1%) was there a marked discrepancy between localized uptake of the two isotopes in the region of a thyroid nodule. Shambaugh et al.$^{12}$ found discrepancies between $^{99m}$Tc and $^{131}$I scans in 3.4% of patients.

We have confirmed that $^{99m}$Tc is a useful tool in assessing thyroid function and anatomy, and that its use compares favourably with techniques where oral $^{131}$I is used. Twenty-minute $^{99m}$Tc thyroidal uptakes are sensitive and reproducible enough to be used for thyrrotrophin stimulation and tri-iodothyronine suppression tests.$^{5,7}$ Moreover, there is a growing awareness of the possible risk from radiation exposure during diagnostic irradiation. The use of $^{131}$I for thyroid scanning results in an estimated dose of 50 - 200 rad;$^{12,13,14}$ such low-dose irradiation of the thyroid has been associated with the greatest occurrence of radiation-induced thyroid cancer.$^{15}$ Thus $^{99m}$Tc has several advantages over the 24-hour radio-iodine test; the radiation exposure is very low (0.1 - 1.8 rad);$^{12,15}$ and therefore it is suitable for repeated tests$^{12}$ and it may well be safer than $^{131}$I; it is cheaper than radio-iodine; it can be used to evaluate thyroid autonomy in patients with hyperthyroidism who are taking antithyroid medication;$^{16}$ thyroid scans are comparable to radio-iodine scans; and patients can be assessed at one clinic visit. Therefore, it is recommended that greater use should be made of technetium both for thyroid uptake measurements and for thyroid imaging.

**REFERENCES**