Thyroid/salivary gland ratio for improvement of Tc-99m thyroid uptake as a test of thyroid function

MM Sathekge*
J Baetens
A Maes
M de Roo
Nuclear Medicine, Katholieke Universiteit Leuven, Belguim
**Also MEDUNSA*

Summary

In order to avoid the problem of significantly underestimating radioisotope uptake, especially in nodular goitre, the thyroid/salivary gland ratio which is independent of background, surface nodularity of the thyroid, population group or geographical area was evaluated in 34 patients. All cases were evaluated by both the 20 minute Tc-99m uptake and the thyroid/salivary gland ratio. The results of the study were compared with laboratory investigation and clinical evaluation. Ninety two percent of hyperthyroid cases were correctly identified by using a thyroid/salivary gland ratio above 7:1. All euthyroid cases had a ratio below 7:1. Twenty minute Tc-99m uptake correctly identified 75% of hyperthyroid and 59% of euthyroid cases, and incorrectly classified 41% of euthyroid cases as hypothyroid. It is recommended that the thyroid/salivary gland ratio be used as a routine screening test as it combines both a functional and a visual display of the thyroid uptake in a more accurate manner.

Introduction

Although the diagnosis of thyroid function is now made primarily by the assay of serum hormone levels, radionuclide uptake tests retain a confirmatory or clarifying role when other tests are ambiguous or contradictory, and are useful adjuncts in the interpretation of thyroid scans. The classical 20 minute Tc-99m uptake has the advantages of being both a diagnostic scan and a thyroid function test, and also saves time and money.[1] Several authors have demonstrated that Tc-99m can be used reliably in uptake and functional studies of the thyroid.[2,3] The reluctance to accept Technetium in this role is largely related to the complexity and methodology required to subtract extrathyroidal background activity in the neck.[1,4] It has also been found that hyperthyroid patients with nodular goitre have significantly lower uptakes than those with diffuse goitre.[5] Furthermore it is known that the normal thyroid uptake levels differ from population to population and from area to area, and that they are dependent on the methodology employed.[6] The present study was designed to show the value of the Tc-99m thyroid/salivary gland ratio as a practical and simple index of thyroid function. The technique's results are not influenced by the extra-thyroidal background, surface nodularity of the thyroid gland, population group or geographical area.[7]

Materials and methods

The study comprised a total of 34 patients (6 males and 28 females) whose diagnoses were determined by clinical and laboratory examinations, including serum T4, T3, TSH and T3 resin uptake. There were 22 euthyroid patients (aged 33 to 81, mean:

to page 13

Thyroid/salivary gland ratio for improvement of Tc-99m thyroid uptake as a test of thyroid function

from page 12

61 years), while 12 hyperthyroid patients were included (aged 17 to 85, mean: 46 years). Tc-99m was used as a tracer, and 5mCi was injected into an antecubital vein. Imaging was completed 20 minutes later using a Siemens large field of view camera with a pinhole collimator, followed by the 20 minute Tc-99m uptake calculation. The uptake was calculated using background and decay-corrected counts in the region of interest around the thyroid. These counts were converted to activity in MBq using a calibration factor obtained from measuring a thyroid phantom with known activity with the same camera set-up. The calculated activity was converted to uptake by comparing it to the patient's known injected activity.

Imaging for the thyroid/salivary gland ratio method was completed using a Gemini 700 camera with high resolution parallel hole collimator. Static uptake images were acquired 20-25 minutes post injection. The field of view included both the submandibular gland and the thyroid. A profile was drawn from the submandibular gland to the hottest area of the thyroid in cases of nodular goitre. The ratio between the maximum activity in the thyroid and the maximum in the submandibular gland was determined from the profile.

Results

The thyroid/salivary gland ratio was compared to the 20 minute Tc-99m uptake. The study results were evaluated by comparison with laboratory results as well as by clinical evaluation (as summarised in Table I). The ratio of the count in the thyroid to that in the submandibular gland is a measure of thyroidal trapping of Technetium. Normally this should be 7:1 or less for euthyroid patients and more than 7:1 in hyperthyroidism.[7] The normal uptake level of Tc-99m at 20 minutes is from 2%-6%. Less than 2% supports hypothyroidism and more than 6% suggests hyperthyroidism.[8] Eleven of the 12 biochemically hyperthyroid patients (92%) were correctly diagnosed by the thyroid/salivary gland ratio, while the classical 20 minute Tc-99m uptake detected 9 of the 12 (75%). The one patient who was biochemically toxic and yet euthyroid on both thyroid/salivary ratio and the 20 minute Tc-99m uptake, had undergone computed tomography scanning with iodinated intravenous contrast prior to scintigraphy (Case 16). The thyroid/salivary ratio detected the biochemically euthyroid patients well. Interobserver variability was absent since all patients were classified into the same group by two independent observers blinded to the biochemical results. The 20 minute Tc-99m uptake incorrectly classified 9 of 22 euthyroid patients (41%) as hypothyroid (Figure 1).

Table I: Results

Case	Sex	Age	Thyroid/Salivary ratio	20 min Tc-99m uptake	Final status
1	M	65	1.7	1.2	Euthyroid nodular goitre
2	F	47	4.9	3.2	Euthyroid nodular goitre
3	F	60	2.0	1.3	Euthyroid without goitre
4	F	40	6.7	3.4	Euthyroid diffuse goitre
5	F	68	2.3	1.0	Euthyroid nodular goitre
6	M	70	3.9	1.6	Euthyroid nodular goitre
7	F	72	3.1	1.4	Euthyroid without goitre
8	F	53	4.7	2.6	Euthyroid without goitre
9	M	51	3.3	1.1	Euthyroid nodular goitre
10	F	42	7.2	3.2	Hyperthyroid nodular goitre
11	F	35	13.5	13.7	Hyperthyroid diffuse goitre
12	F	47	1.5	0.6	Euthyroid nodular goitre
13	F	58	1.7	0.8	Euthyroid nodular goitre
14	F	28	7.5	7.9	Hyperthyroid diffuse goitre
15	F	70	7.7	10.1	Hyperthyroid nodular goitre
16	F	46	2.5	2.8	Hyperthyroid nodular goitre
17	F	17	35.1	45.7	Hyperthyroid diffuse goitre
18	F	37	16.2	9.3	Hyperthyroid diffuse goitre
19	M	46	4.7	5.0	Euthyroid without goitre
20	F	52	4.8	2.1	Euthyroid without goitre
21	F	72	2.5	2.4	Euthyroid without goitre
22	F	40	9.3	8.2	Hyperthyroid diffuse goitre
23	F	70	9.2	8.9	Hyperthyroid nodular goitre
24	F	43	8.2	7.2	Hyperthyroid diffuse goitre
25	F	53	3.9	3.6	Euthyroid without goitre
26	F	71	5.6	3.1	Euthyroid diffuse goitre
27	F	39	12.4	5.1	Hyperthyroid nodular goitre
28	F	33	6.3	3.9	Euthyroid diffuse goitre
29	F	74	2.1	0.7	Euthyroid nodular goitre
30	F	61	4.9	2.3	Euthyroid without goitre
31	M	68	2.3	3.2	Euthyroid nodular goitre
32	F	81	2.5	4.1	Euthyroid diffuse goitre
33	F	85	10.8	17.7	Hyperthyroid nodular goitre
34	M	50	2.4	3.1	Euthyroid nodular goitre

- Thyroid/salivary ratio: euthyroid 7:1 or less, hyperthyroid more than 7:1
- 20 min Tc-99m uptake: euthyroid 2%-6%, hyperthyroid more than 2%, hypothyroid less than 2%.
- Final status: determined by laboratory examination and clinical evaluation.

to page 14

Thyroid/salivary gland ratio for improvement of Tc-99m thyroid uptake as a test of thyroid function

from page 13

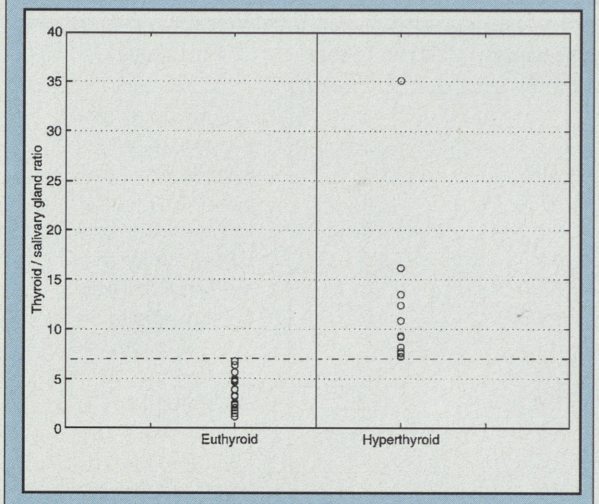

Figure 1(a): Thyroid/salivary gland ratio shows no overlap between euthyroid group and hyperthyroid group. The normal ratio is below 7:1. (Case 16 omitted)

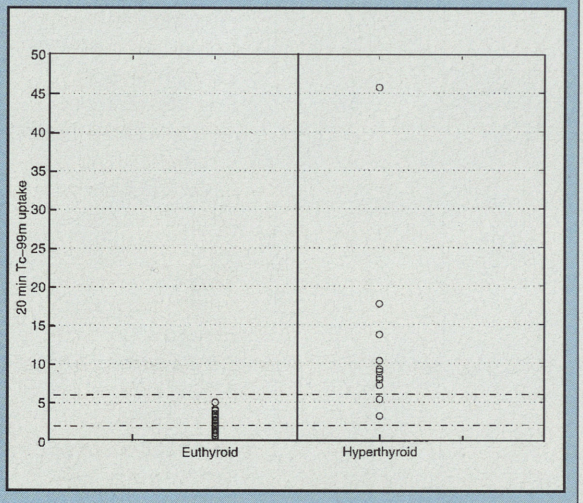

Figure 1(b): 20 min Tc99-m uptake shows overlap between the euthyroid group and the hyperthyroid group The normal uptake level is from 2%-6%. (Case 16 omitted)

Seven of these 9 patients had nodular goitres. This further emphasizes the fact that uptake measurements are significantly underestimated by 20 minute Tc-99m uptake in nodular goitres.

Discussion[9]

Radionuclide uptake tests are relevant to the diagnosis and treatment of thyroid disease. Their role in the management of hyperthyroidism is acknowledged.[4,10,11] The most common causes of hyperthyroidism, namely Grave's disease and toxic nodular goitre, are associated with increased trapping of radionuclides by the thyroid gland[12]. As a result, these causes of hyperthyroidism are amenable to treatment with radio-iodine.[5,13] In contrast, there are many causes of thyrotoxicosis with classic biochemical findings of high levels of circulating thyroid hormones and suppressed TSH in which the radionuclide uptake by the thyroid is low rather than high. None of these conditions is particularly common and most cannot and should not be treated with radio-iodine.[14] Syndromes of thyrotoxicosis with low isotope uptake include subacute thyroiditis and factitious hyperthyroidism. Although I-123 would be an ideal tracer to determine thyroid uptake measurement since it is physiological, its drawbacks include not being easily available, its expense and I-124 contamination.[6] Therefore many physicians still use Tc-99m for uptake measurements, even though it is only trapped without organification. It also has the advantages of being easily available, cheap, and delivering less radiation to the patient than radio-iodine.[15] The 20 minute Tc-99m uptake has been shown to be diminished in nodular goitres.[4,5,12,13] The complexity and methodology of subtracting extrathyroidal background activity in the neck also contribute to the reluctance in accepting 20 minute Tc-99m uptake as a standard test.[1,4] These factors could lead to suboptimal management of patients with thyroid disease, especially in those with hyperthyroidism. Our findings also confirm this in the patient with the thyroid/salivary gland ratio and biochemistry indicating hyperthyroidism and yet a euthyroid 20 minute Tc-99m uptake (Figure 2). Furthermore, the 20 minute

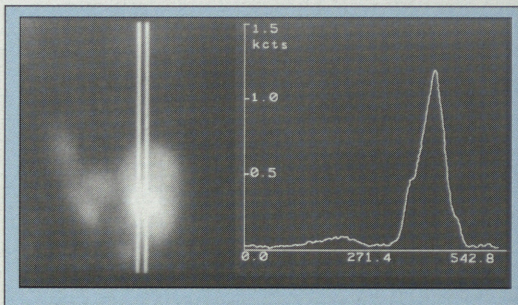

Figure 2:Toxic nodular goitre with thyroid/salivary gland ratio above 7:1 despite a normal 20 min Tc-99m uptake level (case 10).

Tc-99m uptake mis-classified patients who were euthyroid on both biochemistry and the thyroid/salivary gland ratio as being hypothyroid. The thyroid/salivary gland ratio correlates well with visual evaluation. In typical thyrotoxic patients the submandibular glands are not visualized (Figure 3), whereas with euthyroid patients the submandibular glands are always visualized (Figure 3).

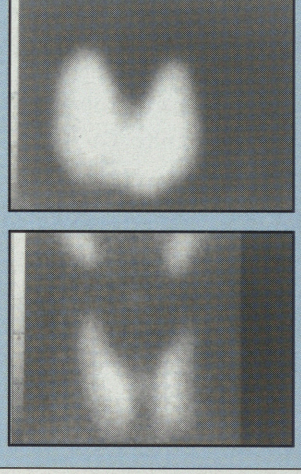

Figure 3: Thyrotoxic gland (above; case 17), and euthyroid gland (below ; case 8).

to page 15

Thyroid/salivary gland ratio for improvement of Tc-99m thyroid uptake as a test of thyroid function

from page 14

Following suppression, the activity in the submandibular glands usually exceeds thyroid activity.[10,13] The overall accuracy of the visual index of thyroid function compared to radio-active iodine uptake is 94%.[16] Another crucial point is that this method is not influenced by the patients' population group or geographical area.[7] Because of the advantages mentioned above the thyroid/salivary gland ratio method should ensure that thyrotoxic patients who could benefit from radio-iodine therapy are not overlooked by the use of alternate methods such as the 20 minute Tc-99m uptake method.

Conclusion

The thyroid/salivary gland ratio method is a simple, reliable and informative test of thyroid function and is preferable in many ways to the 20 minute Tc-99m uptake studies in the diagnosis of hyperthyroidism, especially in cases of nodular goitre. The information provided by the thyroid/salivary gland ratio is complementary to *in vitro* thyroid function tests and is important in differentiating subacute thyroiditis and factitious hyperthyroidism from Grave's disease and toxic nodular goitre, hence assisting in correctly identifying patients for I-131 therapy. The method is also suitable as a routine screening test as it combines a functional and visual display of the thyroid gland without any additional time to the patient.

References

1.Schneider PB. Simple, rapid thyroid function testing with Tc-99m pertechnetate-thyroid uptake ratio and neck/thigh ratio. *AJR* 1979;**132**:249-253.

2.Atkins HL. Technetium-99m pertechnetate uptake and scanning in the evaluation of thyroid function. *Semin Nucl Med* 1971;**1**:345-355.

3.Preston D. Additional experience with pertechnetate as a test of thyroid hyperfunction (abst). *South Med J* 1970;**63**:1373.

4.Selby JB, et al. The use of the Tc-99m pertechnetate neck/thigh ratio as a test of thyroid function. *Radiology* 1975;**114**:107-110.

5.Kirkegaard C, Fris TH, Molholm Hanson JE, Siersbaek-Nielson K. The diagnostic and prognostic value of the 20 min Tc-99m uptake in the thyroid gland. *Acta Endo* 1973;**74**:659-665.

6.Chervu S, Chervu L, Goodwin PN, Blaufox MD. Thyroid uptake measurements with I-123: problems and pitfalls: concise communication. *J Nucl Med* 1982;**23**:667-670.

7.Clauss RP. Endocrinology. *In Nuclear Medicine Clinical Lectures.* 1st ed. Pretoria:1994:260-261.

8.De Roo M, Mortelmans L, Baetens J, Bauwens J: Personal communication.

9.Harden RMcG, et al. Uptake and scanning of salivary glands in man using pertechnetate Tc-99m. *Clin Sc* 1967;**32**:49-55.

10.Hamburger JI, Hamburger SW. Diagnosis and management of large toxic multinodular goitres. *J Nucl Med* 1985;**26**:888-892.

11.McDougall IR. The importance of obtaining thyroid uptake measurement in patients with hyperthyroidism. *Nucl Med Commun* 1990;**11**:73-76.

12.Gorman CA, Robertson JS. Radiation dose in the selection of I-131 or surgical treatment for toxic thyroid adenoma. *Ann Intern Med* 1978;**89**:85-90.

13.Arkles LB. Quantitative thyroid scanning: a reliable thyroid function test. *Am J Roentgenol* 1974;**121**:705-713.

14.Himsworth RL. Hyperthyroidism with a low intake. *Clin Endocrinol Metab* 1985;**14**:397-415.

15.Higgins HP, Ball D, Eastham S. 20-min Tc-99m uptake: a simplified method using the gamma camera. *J Nucl Med* 1973;**14**:907-911.

16.Sostre S, Parikh S. A visual index of thyroid function. *Clin Nucl Med* 1979;**4**:59-63.