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Role of Nuclear Tracers in the Diagnosis and Management of Thyroid Nodules and Ectopic Thyroid Tissue

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Abstract

Scintigraphy studies are very important in assessing the structure and function of thyroid gland whether it involves diagnosis or management. Thyroid scans usually conducted with TcO4-99m yield functional information valuable in the differential diagnosis of thyroid nodules. The most important role in management of nuclear medicine is pertinent to postoperative management of thyroid cancer patients.

Keywords: Scintigraphy; Thyroid scan; Nuclear medicine

Introduction

The thyroid gland structure and function can be assessed using uptake and scintigraphy studies. ^{131}I-iodide is the first radiopharmaceutical which was used for measuring thyroid uptake, and it is noted that for many years it was the main study agent used in the assessment of thyroid gland function [1].

Iodine-123 is a good alternative for iodine-131 since it is known to have a shorter half-life. Technetium¾99m, in the chemical form of pertechnetate ($^{99m}TcO_4$-), is also used for thyroid scintigraphy and uptake. The reason for the uptake of Technetium^{99m} by the thyroid gland is that it's volume and charge resembles the iodide ions [2,3].

Though the lab evaluation of the thyroid function has come a long way in clinical medicine, thyroid scintigraphy is still used in situations like detecting ectopic thyroid tissue in neck masses, improving the chances of detecting hyperthyroidism in complex cases, functional assessment of single/multiple nodules, hyper functioning struma ovarii on the basis of higher uptake of the radionuclide by the ovarian mass compared with the thyroid gland and also calculation of therapeutic doses of ^{131}I-iodide [4,5].

Diagnostic importance in ectopic thyroid tissue

Ectopic thyroid tissue is an infrequent congenital anomaly that is defined, as thyroid tissue not placed antero-laterally from the second to the fourth tracheal cartilage. The most common type of ectopic thyroid is the lingual thyroid. Other places where ectopic thyroid may be found are lateral aberrant thyroid, suprahyoid and infrahyoid, substernal goiters, and struma ovarii. Scintigraphy, using Tc-99m, I-131, or I-123, is the most important diagnostic tool to detect ectopic thyroid tissue and shows the absence or presence of thyroid in its normal location. It is both sensitive and specific for differentiation of an ectopic thyroid from other causes of midline neck masses [6]. However it is known that there is always a possibility of false positive results which may be attributed to either normal or abnormal uptake in the head and neck. Physiological uptake of nuclear tracers is found in intestine, salivary glands, liver, urinary bladder, nasal mucosa and pathological uptake is found in dacrocystitis, meningiomas and sinusitis [7].

Diagnostic role in thyroid nodules

Thyroid scans usually conducted with TcO4-99m yield functional information valuable in the differential diagnosis of thyroid nodules. Based on the uptake of the radioactive material nodules are divided into 'cold', 'iso-functioning' and 'hot' nodules. Radioisotope thyroid scan is indicated if serum TSH is suppressed and in nodules with a 'follicular neoplasm' cytological report. The presence of a low or low-normal serum TSH concentration, a radio-nuclear scan should be done directly compared with the US to establish functionality of each nodule larger than 1.5 cm.

Scintigraphy studies in different population have revealed different results. The scintigraphy study of about 60% the solitary nodules which were detected by the US in the people aged 41-71 in an area with borderline iodine deficiency revealed cold nodules in about 46%, normal function nodules in 44%, and hot nodules in 6% [8]. In another population, the thyroid nodules were detected by the thyroid examination of people aged 18-64 in only about 1.9% in an iodine sufficient area and in 5.1% in an iodine deficient area. The scintigraphy study of these nodules identified cold nodules in 87 and 84%, isofunctioning in 0.4 and 0.6%, and hot nodules in 8 and 10% in the iodine sufficient and deficient areas respectively [9]. In most cases hot nodules are easily detected by a TSH lab test but in iodine deficient places, scintigraphic evidence for thyroid autonomy has been reported in 40% of patients with euthyroid endemic goiters [10]. Somatic constitutively activating TSH receptor mutations have been detected by autoradiography [11]. Therefore it likely that not all 'hot' nodules which are more common in iodine deficient areas are found by TSH levels [12] but when hot nodule volume is more than 16 ml, a suppressed TSH was detectable even with older Radioimmunoassay techniques [13].

Cold thyroid nodules are not infrequent and generally due to benign diseases. To differentiate the ones denoting carcinomas, classes of risk need to be selected derived from numerous factors, which encompass sex, age, iodine intake, external radiation exposure and thyroid morphology. Additionally these patients will undergo fine needle biopsy to arrive at the final diagnosis. Its preciseness is often chosen as a first line modality in the diagnostic approach to thyroid nodules. Tumour imaging agents (PET-CT) are very helpful in the staging and follow-up of thyroid carcinomas, but are rarely needed in the primary diagnosis of the disease [14,15].

Role in the management of thyroid related diseases

The most important role in management of nuclear medicine is pertinent to postoperative management of thyroid cancer patients. The approach is based on involvement of different specialists like the surgeon, endocrinologists, and nuclear medicine specialist. Various studies have given different results signifying the importance of nuclear therapy.

For low risk patient diagnosed with PTC post operatively thyroid suppression is started immediately with an aim to keep TSH levels in a range of 0.1 to 0.4 mIU/L, so no radioiodine therapy or scan is required and the follow up includes only physical examination of the neck yearly twice.

It is also noted that for intermediate and high risk patients with DTC who had total or near total thyroidectomy a post operative treatment study was done. The two options were liothronine 25 ug qd or bid and withdrawal for 2 weeks, and recombinant TSH injections 0.9 mg twice on consecutive days 24 hrs prior to I^{131} to raise the TSH levels above 25 mIU. It was found in that particular study that 84% of those prepared by recombinant TSH, and about 81% of those prepared by hormone withdrawal, had total resolution of visible thyroid bed uptake after Radioiodine remnant ablation (RRA) [16]. It was followed by a whole body scanning to determine the presence of metastases. It was found contradictory to the previous beliefs of high dose efficacy, the low dose of 1100 Mbq radioiodine activity is sufficient for thyroid remnant ablation as contrast to 3700 MBq radioiodine activity with similar quality of life, fewer common adverse effects, and a short hospital stay [17]. It was reported that diagnostic scanning can be repeated after 12 months to report any residual uptake which may require a repeat high dose ablation. In few patients with aggressive diseases, scanning can be repeated every 6 months. And it was also concluded that all patients who undergo surgery and remnant ablation receive thyroid hormones indefinitely to suppress TSH levels below 0.1 mIU/L. The follow up included yearly twice neck physical examination and serum thyroglobulin levels and it was concluded that whole body radioiodine scans to be done only in patients whose serum thyroglobulin levels rise above 5 ng/ml during suppressive thyroid replacement or above 10 ng/ml when hypothyroid.

Though a study reported that all individuals with well differentiated thyroid cancer recurrence who received a second therapeutic dose of radioactive iodine may be beneficial [18], results are inconsistent among various centers. The additional benefit of remnant ablation in low risk patients managed by bilateral thyroidectomy and thyroid hormone suppressive therapy was unclear as reported by another study [19]. Bone metastases was unaffected by radioiodine and it could only be managed by radiotherapy for palliation [20].The usage of radiolabelled somatostatin analogs has also been proposed which are able to demonstrate uptake in the tumour [21].

Conclusion

Though the lab evaluation of the thyroid function has come a long way in clinical medicine, thyroid scintigraphy is still used in situations like detecting ectopic thyroid tissue in neck masses and improving the chances of detecting hyperthyroidism in complex cases.

Scintigraphy studies are very important in assessing the structure and function of thyroid gland whether it involves diagnosis or management. Thyroid scans usually conducted with TcO4-99m yield functional information valuable in the differential diagnosis of thyroid nodules. The most important role in management of nuclear medicine is pertinent to postoperative management of thyroid cancer patients.

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