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Pitfalls and Limitations of Radionuclide Imaging in Endocrinology

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Several different techniques, radiopharmaceuticals, and imaging modalities are commonly used in nuclear medicine for studies of endocrine organs. Nuclear medicine is used in the management of benign and malignant thyroid, parathyroid, and neuroendocrine disorders. Thus, it is essential to acknowledge pitfalls and the limitations of nuclear medicine imaging for accurate diagnosis and patient management.
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Introduction

Since the very early days of nuclear medicine, radionuclide imaging has been used in endocrinology, with most investigation relating to thyroid disorders. With advancement in technology and discovery of new tracers, nuclear medicine imaging is now an essential part of any diagnostic and decision algorithm in various endocrine disorders. In this review article, we elaborate on the various pitfalls and limitations of nuclear medicine imaging in benign and malignant thyroid, parathyroid, and neuroendocrine disorders.

Pitfalls in Imaging in Benign Thyroid Disease

Thyroid scintigraphy remains an important imaging modality in day-to-day endocrine clinical practice. The common indications for benign thyroid disease are differentiation of Graves' disease and other forms of thyrotoxicosis, for example, from thyroiditis, determination of function of a thyroid nodule, identification of ectopic thyroid tissue, evaluation of congenital hypothyroidism, characterization of a neck or mediastinal mass, etc. The radiotracers used in thyroid imaging are provided in Table 1.

Technical Factors

Inaccurate data input while computing the thyroid uptake function may lead to wrong estimation. For example, if the sensitivity of a collimator or the residual tracer activity within the syringe is wrongly documented, error in thyroid uptake measurement occurs. In addition, tracer extravasation can lead to wrong uptake estimation. In most cases, visual interpretation of the thyroid image may suggest discordant image findings and estimated function.

Patient Movement

Patient movement may lead to blurring of the image or falsely project uptake at 2 different sites (Fig. 1). This is particularly problematic in presence of cold nodules and ectopic thyroid in children. Thus, any patient movement while scanning should be noted and acquisition repeated.

Factors Influencing Thyroid Uptake

Different drugs may affect the uptake of tracer within the thyroid as mentioned in Table 2 (Fig. 2).[1,2] Moreover, the thyroid uptake is influenced by various diseases and food (Table 3).[2,3] Therefore, it is essential to take note of drug and

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Table 1 Characteristics of Radiopharmaceuticals Used in Thyroid Imaging

	^{99m}Tc-Pertechnetate	^{123}I-Iodide	^{131}I-Iodide
Physical half-life ($t_{1/2}$)	6 h	13.2 h	8.1 d
Photon energy	140 keV	159 keV	364 keV
Beta emission and energy	No	No	Yes (606 keV)
Mechanism of uptake	Trapped by the thyroid	Trapped and organified	Trapped and organified
Advantages	Easily available Less expensive Quicker examination Low radiation burden	Good for visualization of retrosternal tissue Better image quality Low radiation burden	Better for therapeutic indications
Disadvantages	No organification	Less readily available	364-keV photons are not optimal for gamma cameras
		Relatively expensive	High-energy beta emissions
	Poor image quality when uptake is low	Delayed imaging at 24 hours is required	Long physical half-life of gamma emissions
	Not good for retrosternal mass characterization	Higher radiation burden compared with ^{99m}Tc-pertechnetate	High radiation dose to the patient limits the amount of activity that can be administered

medical history to avoid incorrect interpretation of a thyroid scan.

Esophageal Activity Mimicking Thyroid Tissue

Esophageal tracer distribution may mimic ectopic thyroid tissue. This may be seen with both ^{99m}Tc-pertechnetate and ^{123}I when used as imaging agents. Usually this is seen just to the left of the midline as the esophagus may be displaced when the neck is hyperextended in the imaging position. Often acquiring additional images after the patient has swallowed water helps in differentiating the esophageal uptake from the thyroid tissue by clearing esophageal activity. If the activity still persists after swallowing water and is strongly suspicious for physiological activity in the esophagus, SPECT/CT may be considered for further clarification.

Cold Nodule

In general, palpable thyroid nodules have been reported in 15% of the population, and solitary nodules present in approximately 3.2% of women and 0.8% of men.[4] The overall likelihood of malignancy in a solitary thyroid nodule is approximately 10%.[5] The role of thyroid scintigraphy is to assess the functional status of a nodule, and relatively hot or cold regions within the thyroid should be noted. A hot nodule is almost always benign and frequently represents a hyperfunctioning adenoma, whereas a solitary cold nodule has a 5%-10% risk of being malignant and requires further evaluation to exclude malignancy.[6]

A photopenic area within the thyroid does not necessarily mean a nodule, which is diagnosed generally by palpation or anatomical imaging. The differential diagnosis of a cold area within the thyroid is discussed (Table 4).[7] It is always important

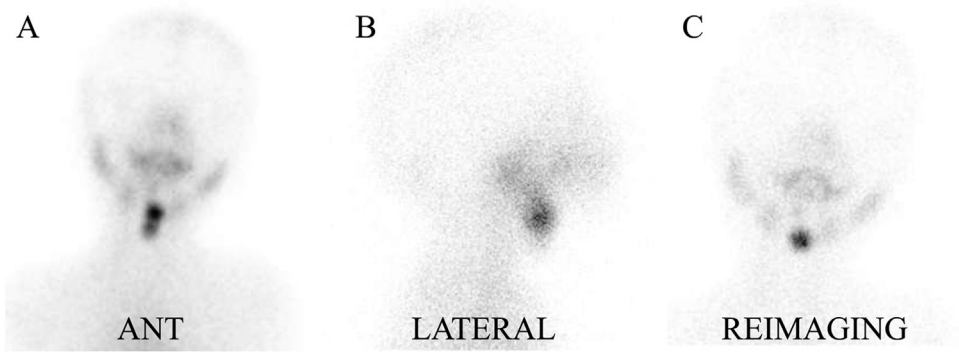

Figure 1 ^{99m}Tc-petechnetate thyroid scan of a child who was under evaluation for thyroglossal cyst showed 2 foci of uptake of tracer in the midline in the anterior image (A). However, the lateral image demonstrated only 1 focus of abnormal uptake (B). The technical staff reported movement of child during image acquisition. Thus, another image of neck was acquired (C), which confirmed single focus of tracer uptake in midline of neck suggestive of functioning thyroid tissue in the thyroglossal cyst. This example illustrates the importance of avoiding and documenting patient movement during image acquisition to prevent false interpretation.