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Role of isotope scan, including positron emission tomography/computed tomography, in nodular goitre

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Nuclear medicine techniques were first used in clinical practice for diagnosing and treating thyroid diseases in the 1950s, and are still an integral part of thyroid nodules work-up. Thyroid imaging with iodine or iodine-analogue isotopes is the only examination able to prove the presence of autonomously functioning thyroid tissue, which excludes malignancy with a high probability. In addition, a thyroid scan with technetium-99m-methoxyisobutylisonitrile is able to avoid unnecessary surgical procedures for cytologically inconclusive thyroid nodules, as confirmed by meta-analysis and cost-effectiveness studies. Finally, positron emission tomography alone, and positron emission tomography combined with computed tomography scans with ^{18}F-fluoro-2-deoxy-*d*-glucose are also promising for diagnosing thyroid diseases, but further studies are needed before introducing them to clinical practice.

Introduction

Nuclear medicine techniques were first used for diagnosing and treating thyroid diseases in the 1950s. Subsequently, with the development of thyroid ultrasound combined with fine-needle aspiration (FNA) for the evaluation of nodular disease, the use of thyroid scintigraphy has decreased.

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Thyroid scintigraphy with either iodine or iodine-analogue isotopes, however, is the only method able to show the presence of autonomously functioning nodules [1]. An increased tracer uptake within a nodule excludes malignancy with high accuracy and, additionally, allows timely and appropriate treatment. More recently, different tracers have become available to evaluate the proliferation rate of the thyroid cells. These have proved to be useful for reducing the number of unnecessary thyroidectomies owing to their high negative predictive values [2,3]. Finally, novel imaging technologies, such as single-photon emission computed tomography (SPECT) and positron emission tomography (PET) are now available, consistently increase the quality of nuclear medicine images, and allow sophisticated quantification procedures [3]. In this chapter, we summarize recent insights into the role of diagnostic nuclear medicine techniques in people with thyroid nodules, and provide practical suggestions for appropriate use of these techniques in daily clinical life.

Radioactive thyroid tracers and nuclear imaging techniques

Thyroid radiotracers can be classified into two groups: (1) radiotracers describing the function of follicular cells; and (2) radiotracers mapping the proliferative activity of follicular cells (Fig. 1).

Radiotracers describing the function of follicular cells

Normal thyroid tissue is characterized by the unique capability of its follicular cells to trap and to process stable iodine (I), which is subsequently incorporated in Tg to form thyroid hormones. The I uptake into the follicular cells is regulated by the sodium iodide symporter (NIS), a trans-membrane protein that carries sodium and iodine from the blood into the follicular cells [4,5]. The NIS allows the thyroid trapping of different radioactive thyroid tracers [6]. Iodine-123 sodium iodide (^{123}I) is an ideal thyroid radiopharmaceutical because of its low radiation burden and optimal imaging quality compared with the use of iodine-131 (^{131}I), which is strongly discouraged for routine diagnostic use because of its much higher radiation burden to the thyroid [7]. Finally, Iodine-124 (^{124}I) is a positron-emitting isotope that allows high-quality imaging of the thyroid. Currently, however, its use is restricted to clinical trials involving individuals with differentiated thyroid cancer, and is not indicated for the diagnostic work-up of people with thyroid nodules. The thyroid uptake of a different tracer, ^{99m}Tc-pertechnetate, is also related to NIS expression. Importantly, it is not a substrate for any

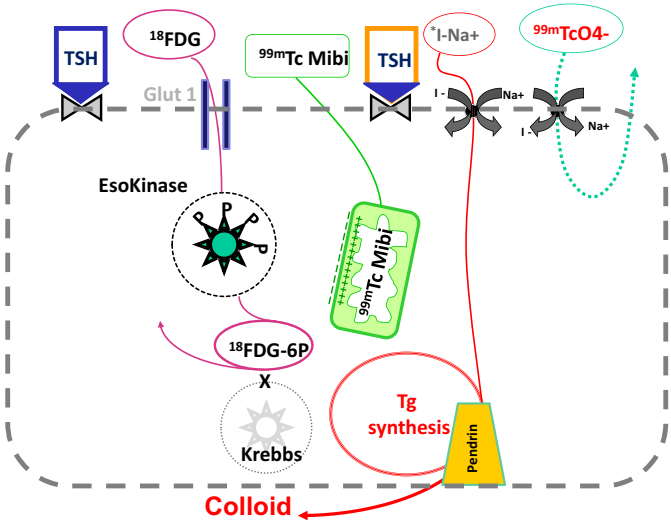

Fig. 1. Nuclear imaging of follicular thyroid cell: molecular basis. ^{18}F-FDG, ^{18}F-fluorodeoxyglucose; ^{18}FDG-6P, ^{18}FDG 6-phosphatase; ^{99m}Tc-MIBI, 99mTc-2-methoxyisobutylisonitrile; $^{99m}TcO_4$-, ^{99m}Tc-pertechnetate; TSH, thyroid-stimulating hormone.