Potential Role of PET/CT in Evaluation of Thyroid Carcinoma Subtypes

Thesis

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ACTH	Adrenocorticotropic Hormone
CT	Computed Tomography
ECM	Extracellular Matrix
^{18}F-DOPA	Fluoro-18-L-Dihydroxyphenylalanine
^{18}FDG	^{18}F-fluorodeoxyglucose
FNAC	Fine Needle Aspiration Cytology
HU	Hounsfield Unit
^{124}I	^{124}Iodine
MALT	Mucosa-Associated Lymphoid Tissue
MRI	Magnetic Resonance Imaging
PET	Positron Emission Tomography
PTEN	Phosphatase and tensin homolog
RAI	Radioactive Iodine
RLN	Recurrent Laryngeal Nerve
ROI	Region of Interest
SLN	Superior Laryngeal Nerve
SUV	Standardized Uptake Value
TSH	Thyroid Stimulating Hormone
US	Ultrasonography

INTRODUCTION

Thyroid cancer is the most common endocrine malignancy. It often presents as a thyroid nodule. Evaluating the nature of a thyroid nodule is typically done through correlating clinical examination findings, serum thyroid stimulating hormone (TSH) levels, and the results of various diagnostic procedures including ultrasound (US) and fine needle aspiration cytology (FNAC) in addition to data obtained from the use of technetium-99m pertechnetate thyroid scintigraphy ***(Nguyen et al., 2018) (Panagiotidis, 2018).***

Thyroid malignancies can be divided into several histological subtypes, differentiated types represent 90% of thyroid cancers. They include papillary subtype, which is the most common subtype (80 - 85%), and follicular subtype ***(Sottoriva, 2018) (Zhang et al., 2018).***

Other subtypes include medullary carcinoma (5%) and anaplastic carcinoma (less than 2%) ***(Araz and Çayır, 2017).***

Poorly differentiated thyroid carcinoma is considered a transitional type falling between differentiated thyroid carcinoma and anaplastic thyroid carcinoma in terms of behavior and histopathological features ***(Araz and Çayır, 2017).***

Thyroid lymphoma is a rare disease constituting 1-5% of all thyroid malignancies and 1-2.5% of all lymphomas. Hürthle cell cancer of the thyroid is another relatively uncommon form (3.6%) ***(Araz and Çayır, 2017).***

^{18}F-fluorodeoxyglucose positron emission tomography–computed tomography (^{18}FDG PET/CT) is a hybrid imaging technique combining ^{18}FDG PET scan and CT scan. CT scan can provide fine anatomical details and ^{18}FDG PET scan assesses metabolic activity at the molecular level as ^{18}FDG uptake by the cells depends on their glycolytic activity. Thus, ^{18}FDG PET/CT combines both functional and anatomical imaging. It is an important diagnostic tool in differentiating benign from malignant lesions, in the work up, staging and post treatment follow-up of malignancy, and in detection of recurrent disease ***(Sheldon et al., 2018).***

Role of ^{18}FDG PET/CT in thyroid carcinoma is still highly debated and not well established. Differentiated thyroid carcinomas have a relatively low metabolic rate and thus they don't avidly uptake ^{18}FDG in ^{18}FDG PET/CT scans. On the contrary, de-differentiated and other types of thyroid carcinomas show a higher glycolytic rate and ^{18}FDG uptake ***(Araz and Çayır, 2017*****).**

The treatment of choice for thyroid cancer is total thyroidectomy with or without lymph node dissection followed by radioactive iodine therapy. Follow-up is done using thyroglobulin (Tg) levels every 6-12 months. A rising Tg level with a negative radioiodine scan warrants an ^{18}FDG PET/CT marking the earliest established indication for it in cases of thyroid carcinoma ***(Garg et al., 2017)***

Other newer indications for ^{18}FDG PET/CT in thyroid malignancies include metastatic workup for de-differentiated and types of thyroid carcinomas other than differentiated types as they show a higher glycolytic rate and thus avid ^{18}FDG uptake ***(Araz and Çayır, 2017).***

The increased use of ^{18}FDG PET/CT in other malignancies lead to the appearance of the new term "thyroid incidentalomas" in which there's an accidentally discovered diffuse or focal increased ^{18}FDG uptake in the thyroid gland reported in about 0.2-8.9% of PET/CT scans. 10-20% of the cases with focal increased uptake turned out to be malignant on FNAC. While the probability of malignancy was much lower in cases with diffuse increased uptake, which were most likely thyroiditis ***(Makis and Ciarallo, 2017) (Manickam et al., 2018).***

AIM OF WORK

To explore the role of ^{18}FDG PET/CT in the evaluation of different subtypes of thyroid carcinoma.

THYROID GLAND ANATOMY

GROSS ANATOMY OF THE THYROID GLAND:

The thyroid is a highly vascular, brownish-red gland located anteriorly in the lower neck at the level of the thoracic inlet, extending from the level of the fifth cervical vertebra down to the first thoracic vertebra. ***(Dorion, 2017).***

The gland varies from an H to a U shape and is formed by 2 elongated lateral lobes - with superior and inferior poles - connected by a median isthmus, with an average height of 12-15 mm, overlying the second to fourth tracheal rings. **(Figure 1)** ***(Dorion, 2017).***

Each lobe is approximately 4 cm in length, 2 cm in width, and 2 to 3 cm in thickness. The isthmus measures about 2 cm in width, 2 cm in height, and 2 to 6 mm in thickness ***(Stathatos, 2019).***

Occasionally, the isthmus is absent, and the gland exists as two distinct lobes ***(Dorion, 2017).***

Although thyroid weight varies, it averages 25-30 grams in adults (it is slightly heavier in women). The gland enlarges during menstruation and pregnancy ***(Dorion, 2017).***

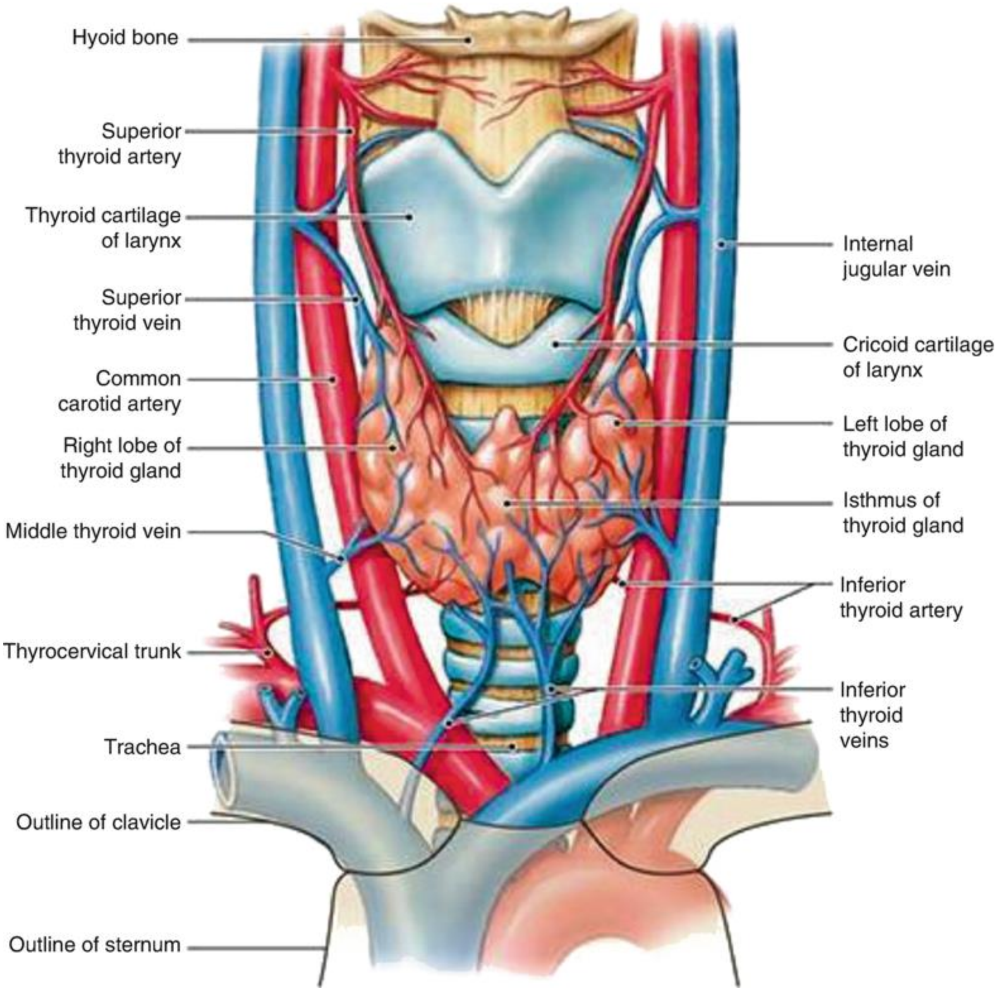

Figure 1: **Thyroid gland anatomy** ***(Stathatos, 2019).***

The parathyroid glands usually lie in a close relationship with the thyroid gland on the posterior aspect of its lobes; there are usually four parathyroid glands; a superior and an inferior gland on either side ***(Stathatos, 2019).***

RELATIONS OF THE LOBES (FIGURE 2):

Anterior relationships:

- Strap muscles (sternothyroid and sternohyoid muscles).
- Sternocleidomastoid (anterolateral).

Posterolateral relationships:

- Carotid sheath containing common carotid artery, internal jugular vein, and vagus nerve.

Medial relationships:

- Larynx.
- Trachea.

Posterior relationships:

- Parathyroid glands.
- Longus coli muscle.
- Recurrent laryngeal nerves.

(Evans, 2000)

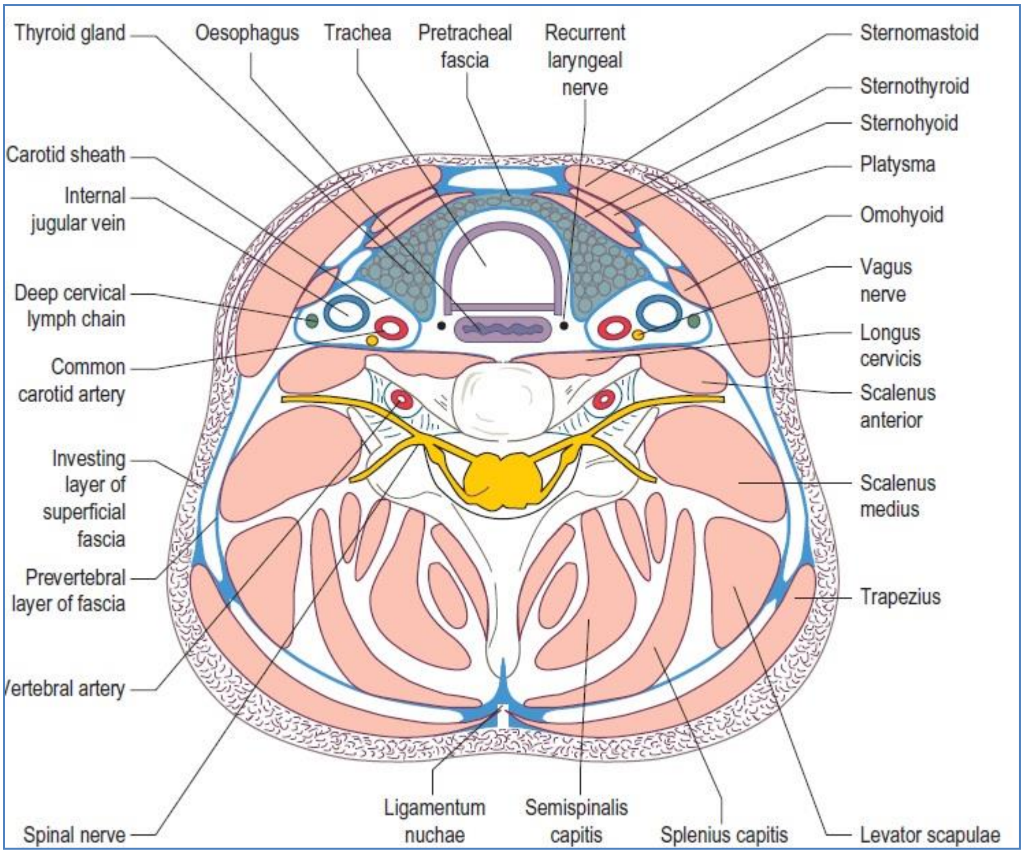

Figure 2: **Transverse section of the neck at the level of C6 showing relationships of the thyroid gland *(Evans, 2000).***

ARTERIAL SUPPLY:

The thyroid gland is supplied by the superior thyroid artery that passes to its upper pole, and the inferior thyroid artery that passes to the posterior aspect of its lower pole. Occasionally, the thyroid ima artery – which is a small and inconstant artery – is present. **(Figure 3)** ***(Youn et al., 2014).***

The superior thyroid artery arises from the external carotid artery and courses inferiorly to the upper pole of the gland