INTRODUCTION

Thyroid nodules are vastly prevalent whereas thyroid cancer is a relatively rare entity. While thyroid nodules are discovered on clinical examination in 3-7% of the adult population, the incidence of detectable nodules on ultrasound (US) is between 30% and 70%, and rises progressively with age. However, only less than 10% of these ultrasound detected nodules are malignant ***(Bahn and Castro, 2011).***

As an easy simple way to diagnose nodules we use ultrasound, but its ability to differentiate benign from possible malignant nodules was an obstacle. There are several recently published guidelines for determining whether a nodule should undergo US-guided fine-needle aspiration cytology (FNAC) on the basis of its US ***(Grant et al., 2015).***

Risk classification models based on US features have been created by multiple professional societies, including the American College of Radiology (ACR), which published the Thyroid Imaging Reporting and Data System (TI-RADS) in 2017 ***(Macedo et al., 2018).***

ACR TI-RADS uses a standardized lexicon for assessment of thyroid nodules to generate a numeric scoring of features, designate categories of relative probability of benignity or malignancy, and provide management recommendations, with the aim of reducing unnecessary biopsies and excessive surveillance ***(Rafel et al., 2019).***

AIM OF THE WORK

The purpose of this study is to evaluate the accuracy of the ultrasound classification system according to Thyroid Imaging Reporting and Data System (TI-RADS), and ultrasonographic classification of the American Thyroid Association (ATA) in characterization of thyroid nodules with the corresponding pathology results as the reference standard.

REVIEW OF LITERATURE

Anatomy and Sonographic Anatomy of the Thyroid Gland

Normal Thyroid Gland Anatomy

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 ***(Dominique, 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)** ***(Dominique, 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 ***(Lai et al., 2005).***

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

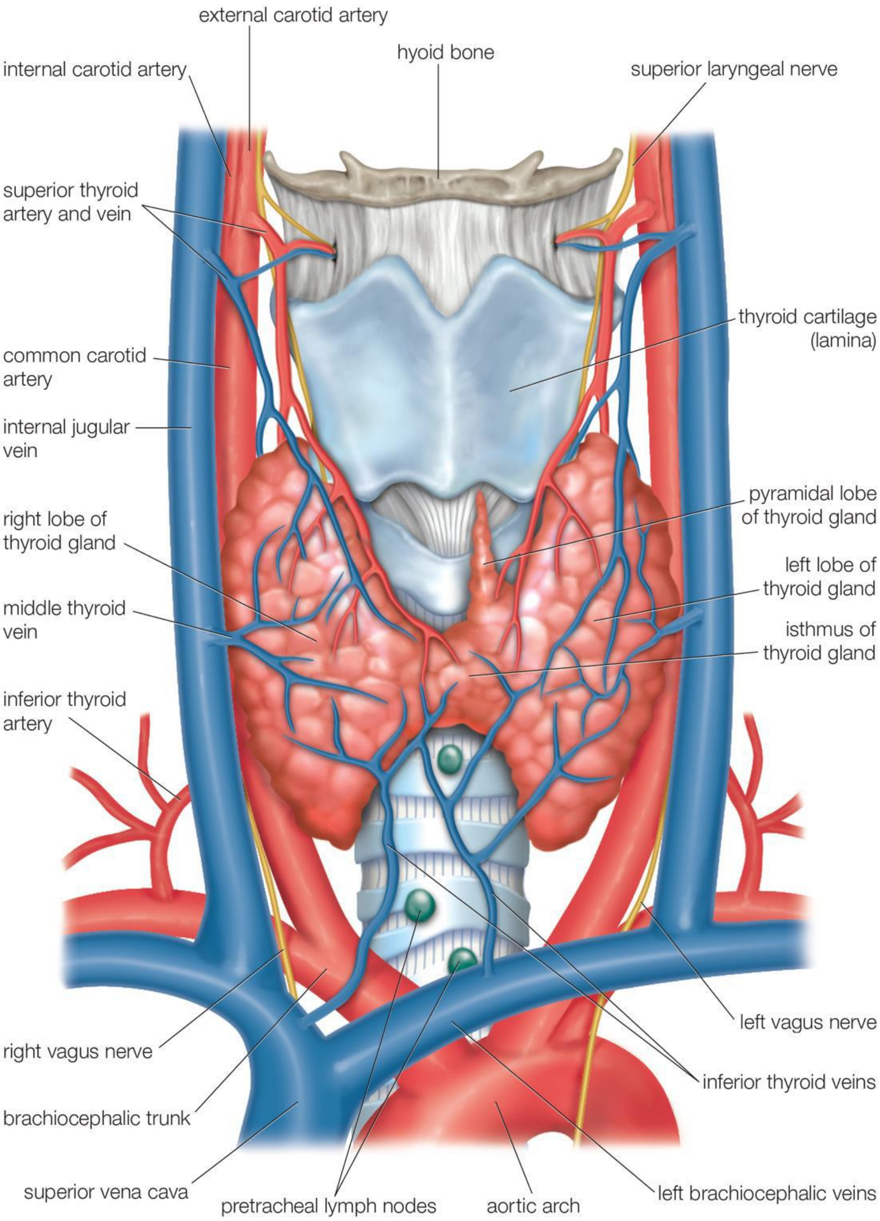


Figure 1: Thyroid gland anatomy ***(Dumont et al., 2015).***

The thyroid gland wraps around 75% of the circumference of the trachea and the most posterior aspects of the lateral lobes may touch the oesophagus. The anterior surface of the thyroid is just deep to the strap muscles of the neck, superiorly the lateral lobes of the thyroid usually extend to level of the middle of the thyroid cartilage and inferiorly the thyroid usually extends to the level of the sixth tracheal ring ***(Robert and Ernst, 2005).***

The thyroid gland is ensheathed by the visceral fascia, a division of the middle layer of deep cervical fascia, which attaches it firmly to the laryngoskeleton. The anterior suspensory ligament extends from the superior-medial aspect of each thyroid lobe to the cricoid and thyroid cartilage. The posteromedial aspect of the gland is attached to the side of the cricoid cartilage, first and second tracheal ring, by the posterior suspensory ligament (Berry ligament). This firm attachment of the gland to the laryngoskeleton is responsible for movement of the thyroid gland and related structures during swallowing ***(Dominique, 2017).***

The parathyroid glands usually lie on the posterior aspect of the thyroid lobes; there are usually 4 parathyroid glands; a superior and inferior on either side, though the numbers vary from 2 to 6. 90% are in close relationship to the thyroid, while 10% almost invariably the inferior glands are aberrant ***(Ellis, 2003).***

Relations of the lobes (Figure 2)

Anterior relationships:

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

Posterolateral relationships:

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

Medial relationships:

- Larynx.
- Trachea.
- Oesophagus.

Posterior relationships:

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

(Ahuja and Evans, 2000)

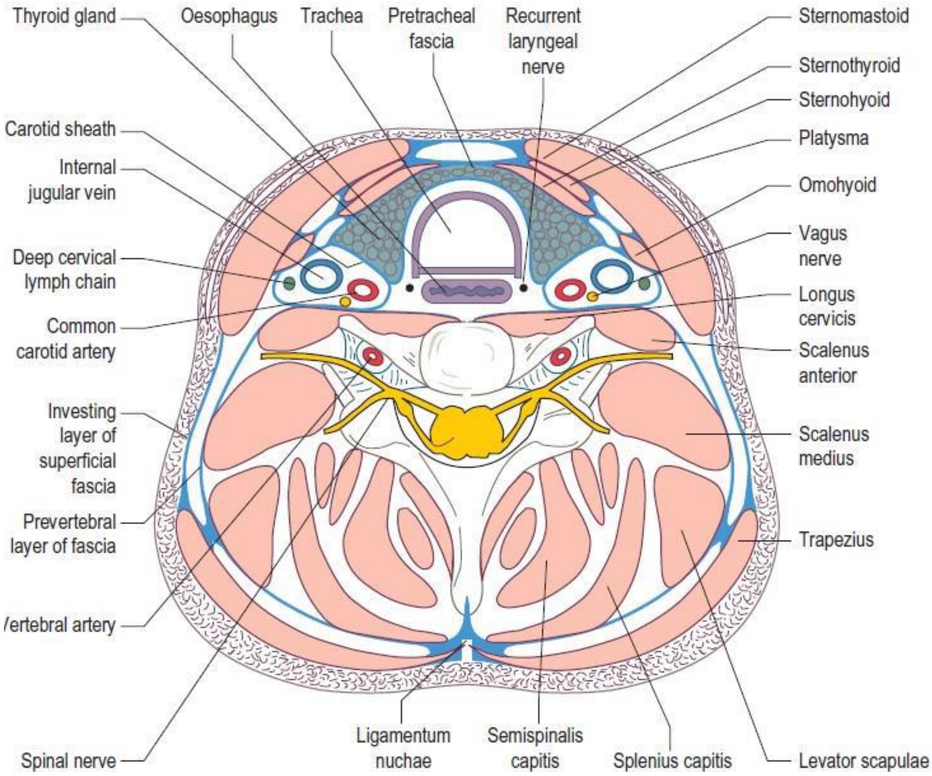


Figure 2: Transverse section of the neck at the level of C6 showing relationships of the thyroid gland ***(Ahuja and Evans, 2000).***

Arterial Supply

Thyroid gland is supplied by the superior thyroid artery which arises from the external carotid and passes to the upper pole, the inferior thyroid artery arises from the thyrocervical trunk of the first part of the subclavian artery and passes behind the carotid sheath to the posterior aspect of the gland and the thyroid ima artery is small and inconstant; when present, it arise from the aortic arch or the brachiocephalic artery **(Figure3)** ***(Ellis, 2003).***

The superior thyroid artery is the first branch of the external carotid artery and courses inferiorly to the upper pole of the thyroid gland. It enters the upper pole of the thyroid on its anterosuperior surface. The inferior thyroid artery usually arises from the thyrocervical trunk and passes upward in front of the vertebral artery and Longuscolli to the lower pole of the thyroid gland. Before entering the thyroid, the artery usually divides into 2–3 branches ***(Yeo-kyu et al., 2014).***

Venous Drainage

Three pairs of veins provide venous drainage for the thyroid gland. The superior thyroid vein drains the upper pole to the internal jugular vein, the middle thyroid vein drains from the lateral side of the gland to the internal jugular and the inferior thyroid veins (there are often several) drain the lower pole to the brachiocephalic veins **(Figure 3)**. Occasionally, both inferior veins form a common trunk called the thyroid ima vein, which empties into the left brachiocephalic vein ***(Ellis, 2003).***

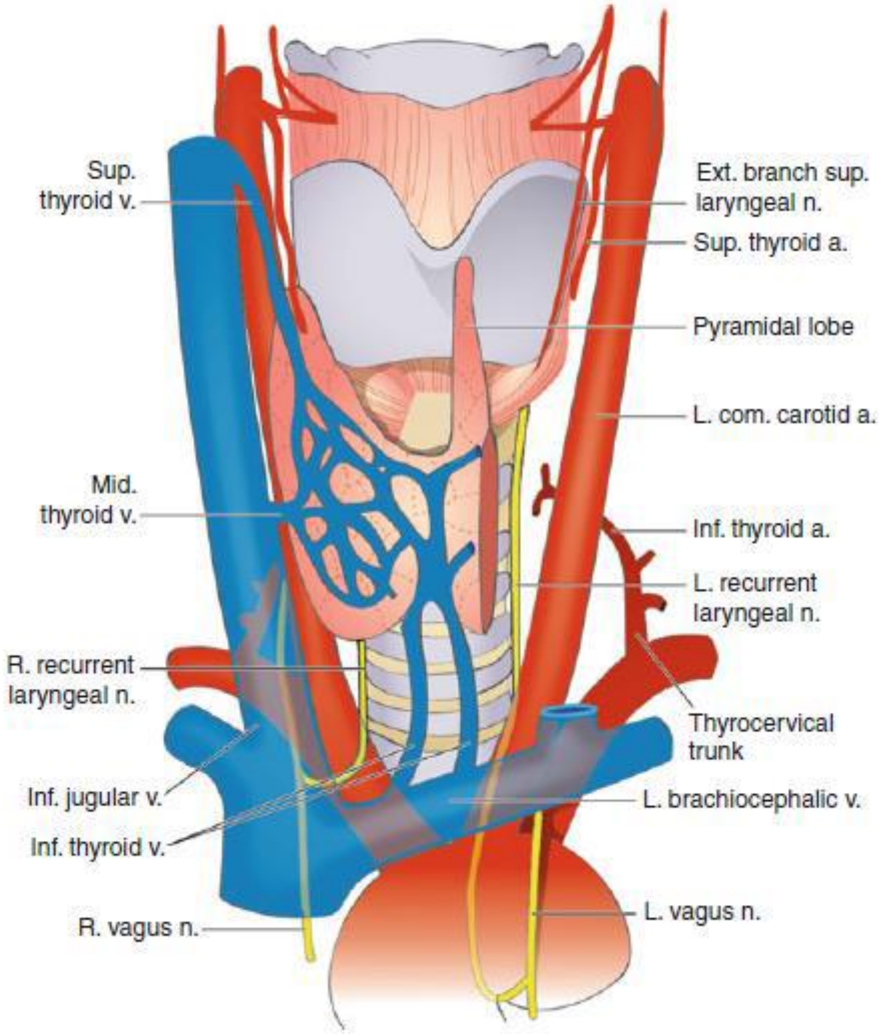
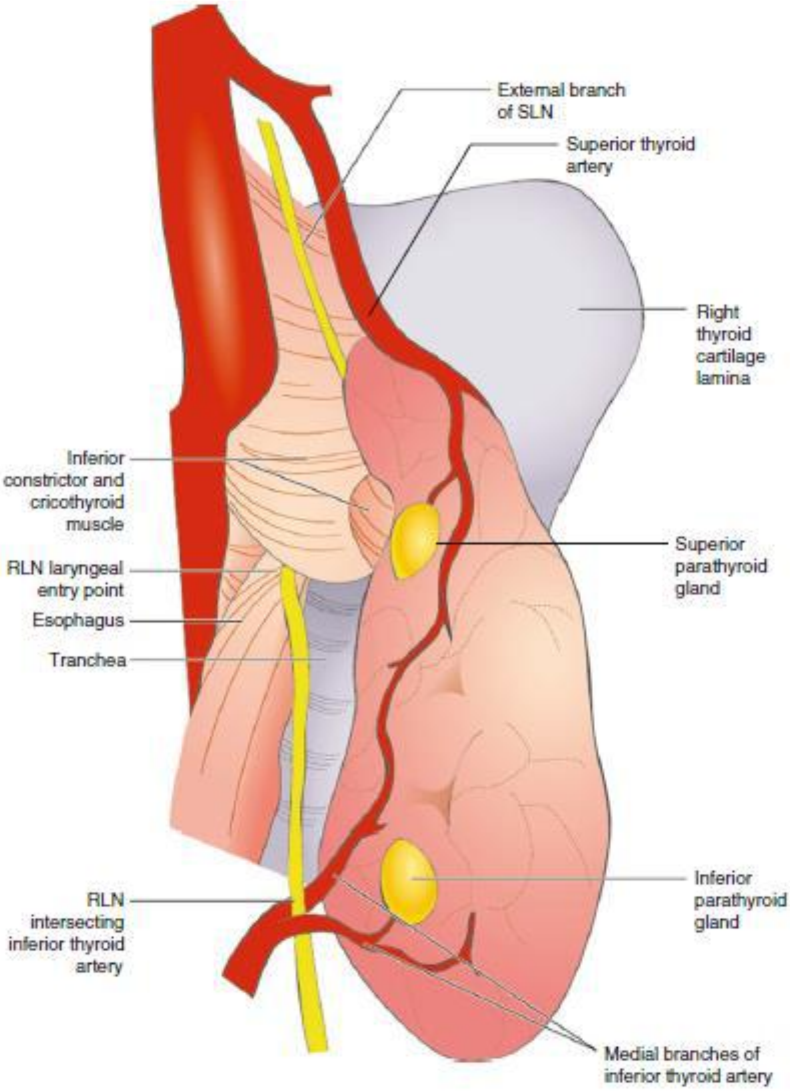


Figure 3: Blood supply and venous drainage of the thyroid gland ***(Yeo-kyu et al., 2014).***

Nerve Supply

Principal innervation of the thyroid gland derives from the autonomic nervous system. Parasympathetic fibers come from the vagus nerves, and sympathetic fibers are distributed from the superior, middle, and inferior ganglia of the sympathetic trunk. These small nerves enter the gland along with the blood vessels. Autonomic nervous regulation of the glandular secretion is not clearly understood, but most of the effect is postulated to be on blood vessels, hence the perfusion rates of the glands **(Figure 4)** ***(Dominique, 2017).***

The relationship of the thyroid gland to the recurrent laryngeal nerve and to the external branch of the superior laryngeal nerve is of major surgical significance because damage to these nerves leads to disability in phonation and/or to difficulty breathing **(Figure 4)**. Both nerves are branches of the vagus nerve ***(Kaplan et al., 2012).***



SLN: Superior Laryngeal Nerve **RLN**: Recurrent Laryngeal Nerve

Figure 4: Nerve supply of the thyroid gland ***(Yeo-kyu et al., 2014).***

Recurrent Laryngeal Nerve (RLN):

Recurrent laryngeal nerves ascend toward the middle of the thyroid gland. They are intimately associated with the inferior thyroid artery. Multiple variations have been described in the relationship of the nerve to the inferior thyroid artery and its branches. The 3 basic configurations include: nerve anterior to the artery, nerve between branches of the artery (found in about 50% of patients on the right), and nerve posterior to the artery (found about 50% of patients on the left) ***(Yeo-kyu et al., 2014).***

During thyroid surgery, identification and preservation of the RLN and all of its divisions is essential to minimize morbidity. The RLN innervates all the intrinsic muscles of the larynx except the cricothyroid muscle and provides sensory innervation to the larynx. Even minor neuropraxia may cause dysphonia; irreversible injury confers permanent hoarseness ***(Panieri and Fagan, 2012).***

External Branch of the Superior Laryngeal Nerve (SLN):

On each side, the external branch of the superior laryngeal nerve innervates the cricothyroid muscle. In most cases, this nerve lies close to the vascular pedicle of the superior poles of the thyroid lobe **(Figure 5)**. In 21%, the nerve is intimately associated with the superior thyroid vessels. In some patients the external branch of the superior laryngeal nerve lies on the anterior surface of the thyroid lobe, making great possibility of damage during thyroidectomy ***(Kaplan et al., 2012).***

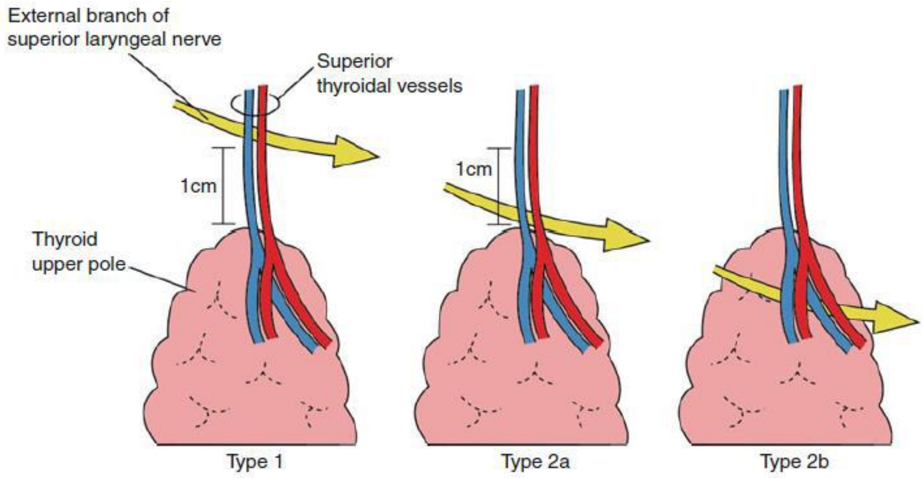


Figure 5: Various relations between external branch of the superior laryngeal nerve and superior thyroidal vessels ***(Yeo-kyu et al., 2014).***

Lymphatic Drainage

Lymphatic drainage of the thyroid gland is multidirectional. Capsular lymph channels, draining the intraglandular capillaries, may cross communicate with the isthmus and opposite lobe. Therefore, it is difficult to predict lymphatic drainage of the thyroid gland ***(Youn et al., 2014).***

In the first place, immediate lymphatic drainage is to the periglandular nodes and it courses to prelaryngeal, pretracheal, and paratracheal lymph nodes; these lymph node groups are called as the central neck compartment. The superior boundary of the central neck compartment is the hyoid bone; the inferior boundary is the suprasternal notch, and the lateral boundaries are the medial border of common carotid artery ***(Youn et al., 2014).***

The second part of lymphatic drainage is the lateral neck region; lymphatic drainage of the superior poles of the thyroid gland can flow directly into the lateral neck nodes, while lymphatic drainage of the other parts flows initially to the central neck nodes. Lateral neck compartment can be subdivided and grouped into several levels. As there exist many classifications of grouping neck lymph nodes, the American Academy of Otolaryngology Head and Neck Surgery Dissection Classification describes six different levels in the central (level IA, IB, and VI) and lateral (IIA, IIB, III, IV, VA, VB) neck **(Figure 6)** ***(Youn et al., 2014).***

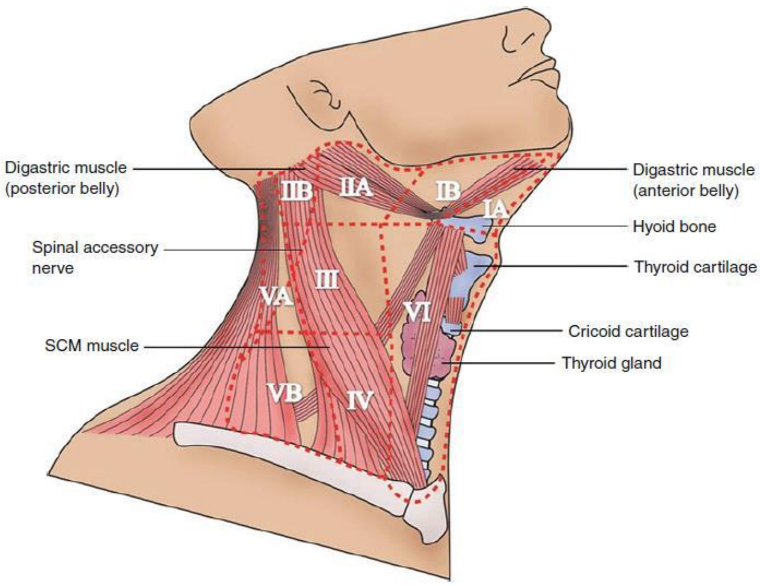


Figure 6: Classification of neck lymph nodes ***(Yeo-kyu et al., 2014).***

The first nodal metastases from thyroid cancer are the nodes of the central compartment of the neck, the nodes of the superior mediastinum, and the lateral cervical nodes. The central compartment nodes are level VI, which is bounded by the hyoid bone superiorly, the suprasternal notch inferiorly, and the carotid arteries laterally. The specific nodal groups that drain the thyroid in the level VI compartment are the paralaryngeal, paratracheal, and prelaryngeal nodes **(Figure 7)**. The level VII nodes are those of the superior mediastinum that lie superior to the innominate vein. The lateral cervical nodes include nodes in both level III and IV ***(Lu and Brady, 2008).***

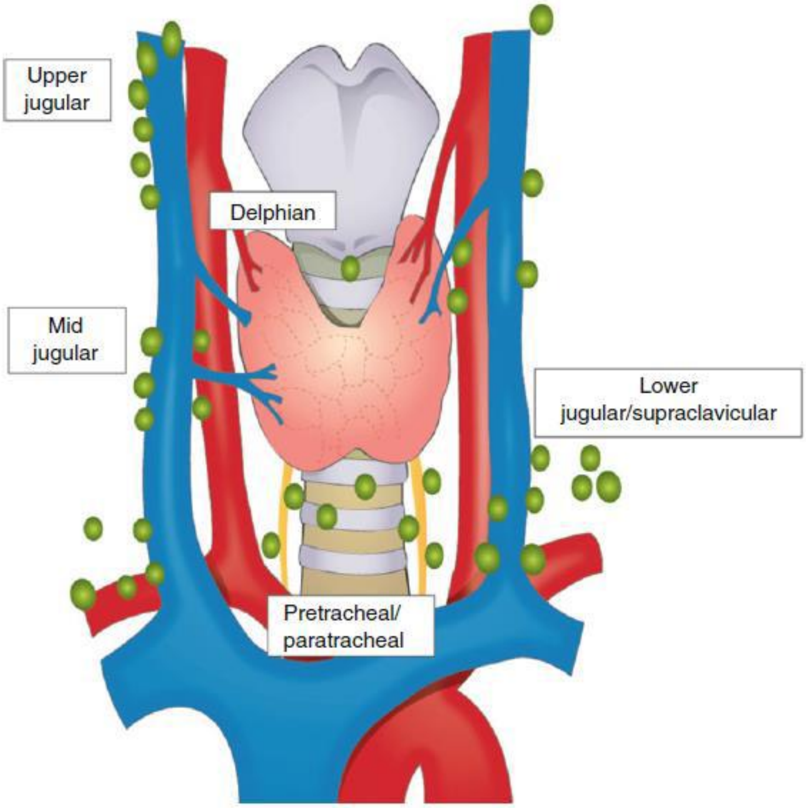


Figure 7: Lymph nodes of importance in thyroid carcinoma ***(Yeo-kyu et al., 2014).***