Sudan University of Science and Technology

Collage of Graduate Studies

Measurement of Thyroid Gland Volume among Women in White Nile State using Ultrasound Imaging

قياس حجم الغده الدرقيه للنساء في ولأيه النيل ألأبيض باستخدام الموجات الصوتيه

Thesis Submitted for Partial Fulfillment of the Requirement of M.Sc Degree in Medical Diagnostic Ultrasound

By:

Abdelraheem Rabih Fadalelsiad Rabih

Supervised by:

Dr/Babiker Abdelwahab Awad Alla

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الآيـة

بسم الله الرحمن الرحيم

قال تعالى :

﴿وَقُلْ رَبِّ زِدْنِي عِلْماً﴾

صدق الله العظيم

الآية [114] سورة طه

Dedication

This Research dedicated

To Soul of my Parents

Who taught me how to make my future

They have given me the drive and discipline to tackle and task with enthusiasm and determination.

To

My family, wife, sons and daughters

To

My sisters

To

My lovely brother Mahieldin Omer Ali

To

Mrs/ Yahya Mohammed yousif

Kenana DMD Operation and his Wife

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My truthful to Dr Alrady X Ray and ultrasound specialist

Last but not least my truthful thanks go out to Dr..Bent Mahyoup to whom .. supporting and helping to complete my project and interest during the length of my research

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Abbreviations

Abbreviations	Full name
T4	Tetraiodothyroxine
T3	Tri-iodothyroxine
Pt-	Patients
C	Cervical vertebra
T	Thyroxine
H&e	Haematoxylin & eosin
TSH	Thyroid Stimulating Hormone
TRH	Throtropin Releasing Hormone
NIIS	Sodium I-Symport
TPO	Thyroid Peroxidase
DIT	Di -iodothyrosine
MIT	Monoiodothyrosine
LH	Luteinizing Hormone
FSH	Follicle Stimulating Hormone
TBG	Thyroxine Binding Globulin
TBPA	Thyroxine Binding Pre Albumin
Na	Sodium
K	Potassium
AP	Antero Posterior
SM	Strap Muscles
LC	Longus Colli
SCM	Sterno-Cleido-Mastoid
Eso	Esophagues
W	Width
CE-US	Contrast Enhancement Ultrasound
D	Depth

L	Length
MATLAB	Matrix Laboratory
TGC	Time Gain Compensation
SPSS	Statistical Package for Social Science

Abstract

This is descriptive cross-sectional study aim to measure normal thyroid volume in women in White Nile State, using SONO Scope Italian company made in China machine using 7-15 MHz transducer in Rabic teaching hospital, the study had 50 normal women aged between 12-50 years old, affected age between 19-30 the mean of aged 27.78, all subject are examined in supine position with neck extended and measure thyroid from outer to inner and measure three plane, transverse, longitudinal, and depth. The main result of this study that affected thyroid volume was 5.1-7 mm percentage 46.3%, and maximum volume thyroid in this study was 9.1-11mm in percentage 14.8%, and minim volume of the thyroid in this study was 3.5 mm percentage 29.6%. The maximum aged of this study was 48 standard deviations (STD) of aged was 8.94. The study found that right lobe maximum volume was 5.5 mm and right lobe minim volume was 2.2 mm, and STD of right lobe was 0.95 and left lobe, maximum volume was 4.5 mm , minim volume was 1.2 mm, with STD was 0.92. The mean of age was 27.78, mean of right lobe was 3.55, and mean of left lobe was 2.27 the total mean of thyroid was 6.12. So that maximum thyroid volume was 10mm The affected thyroid volume was 5.1-7 mm in affected aged group 19-30 years old, the result shows the linear positive correlation between the right lobe and subject age with R2= 0.768 and positve correlation between left lobe and subject aged with R2= 0.676 so that the study shows that there is positve correlations between thyroid volume and aged. The study conclude that the normal thyroid volume increase with aged increase and there was small

increase in right lobe volume than left lobe volume, the study recommended that to increase sample size and using advance ultrasound imaging, and other study with other imaging modalities as comparative studies

مستخلص ألدراسة

هذه دراسة وصفيه تحليليه هدفت ألي قياس حجم ألغده ألدرقية ألطبيعي للنساء بولاية ألنيل ألأبيض باستخدام جهاز سوني سكوب (من شركه ايطاليه \ صناعه صينيه) ببروب خطي قوته 7-15 ميغاهيرز, أجريت هذه ألدراسة بمستشفي ربك ألتعليمي وكانت العينة عبارة عن 50 إمرة سليمة تتراوح أعمارهن بين 12-50 سنه وكان العمرالموثر يتراوح بين 19-30 ومتوسط الأعمار تقريبا هو 28 سنه واجري الفحص لجميع النساء في وضع الاستلقاء علي الظهر مع رفع الرقبة قليلا وذلك لقياس الغده لهم من جميع الاتجاهات وتم اخذ المقاسات من ثلاث مناطق هي الطول والعرض والسمك ومنها تم قياس الحجم الطبيعي وذلك بأخذ النسبة بينهم. ومن أهم نتائج هذه الدراسة إن الحجم الموثر للغده الدرقيه في هذه العينة يتراوح بين 5.1-7مم وذلك بنسبة 46.3% , وكان اكب حجم للغده الدرقيه في هذه العينة يتراوح بين 9-11 مم بنسبه 14.8% , واقل حجم يتراوح بين 3-5 مم بنسبه 29.6% وكان اكبر عمر لهولا النساء هو 48 واقل عمر هو 12 سنه . وجدت الدراسة إن حجم الفص الأيمن للغده الدرقيه في هذه العينة يتراوح بين 2.2-5.5 مم وبانحراف معياري قدره 0.95, والفص الأيسر لهذه الغده حجمه يتراوح بين 1.2-4.5 مم وبانحراف معياري قدره 0.92. وأوضحت الدراسة أن متوسط ألحجم ألكلي للغده ألدرقية في هذه ألعينه هو 6.12 بانحراف معياري مقدره و 1.48 وأكبر حجم للغده هو 10 مم واقل حجم لها هو 3.4 مم. ومن نتائج هذه الدراسة انه يوجد معامل ارتباط موجب بين العمر وحجم الغده ألدرقية في هذه ألعينه.

خلصت ألدراسة ألي أن حجم الفص ألأيمن أكبر من ألأيسر وأن هنالك علاقة بين حجم الغده الدرقيه لهولأء النساء وأعمارهن حيث أنه كلما زاد ألعمر زاد حجم ألغده ألدرقية.

أوصت ألدراسة بان تجرءا دراسة تشتمل علي عينة اكبر وتستخدم فيها ألتقنيات ألحديثه وتحتوي علي دراسة مقارنه بين ألنساء والرجال ومقارنه ب ألتقنيات ألحديثه.

Chapter one

Introduction

The thyroid gland weighs about 15−60 g, it consists of two lobes joined by an isthmus and lies below the larynx on each side of the trachea. The gland is enclosed in a connective tissue capsule and is divided into lobules by connective tissue. The lobules are made up of numerous *tubular spaces* (*follicles*) of varying size, lined with glandular epithelial cells, in which large quantities of hormone can be stored. When the need arises, the hormone can be taken up again by the epithelial cells of the gland and secreted into neighboring blood vessels. The hormones secreted by the thyroid gland, *thyroxine* (T4, tetraiodothyronine) and *triiodothyronine* (T3) are distinguished by their iodine content. Their action is to stimulate cellular metabolism. Triiodothyronine is the actual active thyroid hormone, generated by the splitting of one iodine atom from thyroxine (Chaudhary 2016). Ultrasound of the thyroid gland is the most effective imaging tool. It allows precise measurements of single or multiple thyroid nodules, definition of whether lesions are likely benign or suspect for malignancy, identification of conditions other than nodular change, and adjacent lymph adenopathy, just to illustrate a few common uses of the modality. Nick 2011 found in ultrasound measurement that different people have different size of thyroid especially in measurement of width, depth and area. So that measurement of thyroid can help in detection of any abnormalities that lead to change size and shape of the gland.(Gharib 2016).

1-2 Problems of the study

There is no references of thyroid volume of women in White Nile State

1-3 Objectives:

1-3-1General objective

To measure thyroid volume in women using ultrasound

1-3-2Specific objectives

*to assess patient age

* to assess patient weight

* to assess thyroid volume

* to correlate between pt. age, gender ,weight , and thyroid volume

1-4 Significant of the study

It helps in early detection of any abnormality in thyroid that lead to increase it volume and help for further evaluation and investigation and put reference of women in White Nile State,

1-5 Over view of the study:

This study consist of five chapter

Chapter one introduction, problem, and objective

Chapter two anatomy . physiology, ultrasound measurement of thyroid and previous studies

Chapter three materials and method

Chapter four result

Chapter five discussion, conclusion and recommendations

Chapter two

2-1Anatomy of the Thyroid Gland

2-1-1Thyroid Gland Embryology

The pharyngeal apparatus is responsible for the formation of numerous parts of the head and neck region . During the 3rd gestational week, there is hypertrophy of the endoderm in the midline of the primitive pharynx, arising from the first pharyngeal arch between the tuberculum impar and copula; at a point later referred to as the foramen caecum. This thyroid primordium subsequently enlarges and is attached to the floor of the primitive pharynx by a hollow tube known as the thyroglossal duct. The duct communicates with the foramen caecum, which is caudal to the tuberculum impar (median tongue bud) and rostral to the copula (hypobranchial eminence). The thyroid primordium progresses to a thyroid placed located at the base of the tongue ; which subsequently forms the thyroid diverticulum near the apical pole of the aortic sac. **(Chung 2012)**

2-1-2Gross Anatomy:

The thyroid gland is a butterfly shaped, vascular, red-brown endocrine gland situated in the midline of the anterior neck. Under normal circumstances, it extends from the level of the 5th cervical vertebra (C5) to the first thoracic vertebra (T1). On average, the gland weighs between 15 to 25 g, and is the largest of the endocrine glands. The irregular structure is encased in the pretracheal part of the deep cervical fascia . It is made up of a central isthmus that connects the right and left lobes of the organ inferomedially. Between the ages of 8 months to 15 years, the thyroid gland appears the same in both males and females. However, the gland is slightly heavier in females over the age of 15 than in male counterparts of similar age. Each lobe is roughly conical in shape, with each apex pointing superolaterally and their bases inferomedially (between the 4th and 5th tracheal rings). At their widest point, each lobe measures about 3 cm in the transverse plane, and 2 cm in the anteroposterior dimension. The lobes are roughly 5 cm long. The isthmus lies above the 2nd or 3rd tracheal cartilages and measures 1.25 cm in both the transverse and vertical planes. In some individuals, there may be a third lobe of the thyroid gland known as the pyramidal lobe. It is also a conical structure that extends from the isthmus up to the hyoid bone. In some cases, it may also arise from the inferomedial aspect of either left or right lobes; but it is more commonly seen arising from the left lobe. (Faller 2004)

A butterfly-shaped organ, the thyroid gland is located anterior to the trachea, just inferior to the larynx. The medial region, called the isthmus, is flanked by wing-shaped left and right lobes. Each of the thyroid lobes are embedded with parathyroid glands, primarily on their posterior surfaces. The tissue of the thyroid gland is composed mostly of thyroid follicles. The follicles are made up of a central cavity filled with a sticky fluid called colloid. Surrounded by a wall of epithelial follicle cells, the colloid is the center of thyroid hormone production, and that production is dependent on the hormones' essential and unique component: iodine. The major laryngeal cartilages provide a scaffold for the thyroid gland, posteromedial, the gland is attached by the lateral thyroid ligaments to the cricoids cartilage. Additionally, the levator glandulae thyroidal (levator of the thyroid gland), which is a fibromuscular structure, also anchors the isthmus or pyramidal lobe to the hyoid bone. **(Chung 2012)**

2-1-3Thyroid Gland Histology

Unlike other endocrine glands that secrete their products directly into the bloodstream, the thyroid gland stores its products in follicles. The follicles are often clustered together to form numerous lobules that forms the parenchyma of each lobe of the thyroid. The lobules are also separated by septae, which are formed by invading parts of surrounding fibrous capsule. The septae also act as a conduit for neurovascular and lymphatic structures to traverse the gland. Each follicle is formed by either simple low columnar or cuboidal epithelium surrounding a central lumen. When the gland is in a dormant state, the epithelium may also be squamous. Thyrocytes (follicular cells) are noted to have a rounded nucleus, and relatively large numbers of organelles (mitochondria, rough endoplasmic reticulum, Golgi bodies, etc.) in-keeping with its function (i.e. protein synthesis and secretion). The rough endoplasmic reticula are more abundant towards the base of the cells, while the Golgi bodies are found towards the apex. **(Chung 2012)**

2-1-4Thyroid lobule

Inadvertently, newly synthesized thymoglobulin, which is temporarily stored in the Golgi apparatus, to be exocytosed into the lumen once the vesicle reaches the cell apex. Apical pole of these cells contains several microvilli. Thymoglobulin is stored as a semi-solid entity known as colloid within the lumen of the follicle. It is one of the key histological features observed on light microscopy, as it stains bright pink with haematoxylin and eosin (H&E). Apically, thyrocytes have numerous zonula occludens (tight junctions), zonula adherens (anchoring junctions), and macula adherentes (spot desmosomes) that holds the cells together. Whether performing from the perspective of otolaryngology or general surgery, the head and neck surgeon with a thorough knowledge of anatomy is ideally suited to perform thyroid ultrasound and assessment of adjacent structures. Similarly, the endocrinologist has a need to understand the conditions affecting the thyroid and parathyroid glands even though a direct surgical intervention is not part of his or her practice realm. In the past, all ultrasound images were obtained in the radiology department, and they were transferred to the clinician as a composite either in an envelope or through a digital format. The static nature of these images was a real limitation in the process and really did little to engage the clinician. In addition, the prohibitive cost of ultrasound units and their size did little to move the technology to an office base. Within the past decade, this has all undergone an accelerated transition. Ultrasound companies have understood the value in this new market and have become flexible in configuring systems to the needs of different specialties The basal lamina on which thyrocytes reside also function as a scaffold for the parafollicular (C cells) that are also found in the thyroid gland. These endocrine cells are slightly larger, and appear paler (takes up less H&E), than the thyrocytes. They also have numerous organelles to support their function of synthesizing and secreting calcitonin, to assist in maintaining calcium homeostasis. Although chiefly occupied by thyrocytes and parafollicular cells, the stroma of the thyroid gland also contains sparse reticular connective tissue . Additionally, there is also a vast network of fenestrated capillaries that are available to carry thyroid hormones to their main circulation so that they can be distributed systemically **(Stephan 2002)** .

2-1-5Neurovascular Supply of the Thyroid Gland

2-1-5-1Arterial Supply

Superior thyroid artery (Arteria thyroidea superior), the superior thyroid artery (arising from the external carotid artery) and the inferior thyroid artery (originating from the thyrocervical branch of the subclavian artery) bring oxygenated, nutrient rich blood to the thyroid gland. Inconsistently, there is also the arteria thyroidea ima that arises directly from the brachiocephalic trunk that also supplies the gland. There are numerous points of intraglandular and periglandular anastomoses between the large vessels and their branches. The superior thyroid artery divides on the gland into an anterior branch that travels towards isthmus and posterior branch that goes down the back of the lobe. They anastomose with ascending branch of inferior thyroid artery. The inferior thyroid artery divides outside the pretracheal fascia into 4-5 branches that pierce the fascia and reach the lower pole of the gland to supply. It is of great importance that the surgeon is aware of the very close relationship between the superior thyroid artery and the external laryngeal nerve. This nerve is very close to the artery at the superior pole. Additionally, the recurrent laryngeal nerve is most often related to the posterior branch of the inferior thyroid artery. Damage to the either nerve is associated with serious complications. Bifurcation of the superior thyroid artery occurs after the vessel pierces the pretracheal fascia to enter the gland. It forms anterior and posterior branches that perfuse the anterior, and lateral and medial, surfaces, respectively. The inferior thyroid artery also bifurcates into ascending (superior) and inferior branches as it approaches the inferior pole of the thyroid gland. They supply the posterior and inferior surfaces. **(Stephan 2002)**

2-1-5-2Venous Drainage

Superior thyroid vein (Vena thyroidal superior), the venous tributaries of this organ coalesce to form superior, middle and inferior thyroid veins. The first of the three vessels arise from the upper pole of the thyroid gland and travels alongside the similarly named artery. It courses towards the carotid sheath and subsequently drains into the internal jugular vein. The middle thyroid vein exits from the lateral side of the gland, bringing deoxygenated blood from the inferior part of the gland and also drains into the internal jugular vein. There is a glandular venous plexus that allows communication between the superior and middle thyroid veins. This pretracheal plexus subsequently gives rise to the inferior thyroid vein. On the left side, the inferior thyroid vein drains to the left brachiocephalic vein . On the right, the inferior thyroid vein takes an oblique course, crosses over the right brachiocephalic artery and may either join the right brachiocephalic vein, or drain directly into the inferior vena cava. **(Stephan 2002)**

2-1-5-3Innervation

Superior cervical ganglion (Ganglion cervicale superius), the sympathetic ganglion chain is a bilaterally paired series of autonomic nerve fibers and their associated cell bodies that is situated on either side of the vertebral column. It is subdivided into cervical, thoracic, lumbar and sacral parts. Both sympathetic ganglia terminate as the coccygeal ganglion at the coccyx. The cervical sympathetic ganglion is further subdivided into superior, middle and inferior ganglia. The largest of the three ganglia is the superior ganglion; extending from C1 to C3. The middle ganglion most frequently occurs at C6, and the inferior ganglion can be found at the C7-T1 junction. While all three ganglia provide autonomic innervation to the thyroid gland and its vasculature, the inferior ganglion also forms a plexus around the inferior thyroid artery. This plexus also interacts with the both external and recurrent laryngeal nerves, which also provides parasympathetic innervation to the gland as well (Chaudhary 2013).

2-1-5-4Lymphatic Drainage

Prelaryngeal lymph nodes (Nodi lymphatici praelaryngeales) it the lymphatic plexus that arises from the thyroid gland also communicates with the tracheal lymphatic plexus. They drain to the Delphian (prelaryngeal) lymph nodes that reside above the thyroid isthmus. There is also subsequent drainage to the paratracheal and pretracheal lymph nodes as well. There is also evidence supporting lymphatic drainage from the thyroid gland to the brachiocephalic lymph nodes near the thymus. The deep cervical lymph nodes receive lymph from the lateral part of the gland. This fluid is carried by lymph channels that travel along the superior thyroid vein. There are also other lymph vessels arising from the thyroid that bypass all lymph nodes and drain directly into the thoracic duct **(Sofferman 2012)**

2-2Parathyroid Glands (Epithelial Bodies)

The four parathyroid glands, or epithelial bodies, lie on the posterior side of the thyroid gland. They are often enclosed in the thyroid capsule, in which case they are not visible from the outside. They are lentil-shaped, flat and oval. Reticular connective tissue and numerous capillaries surround the cells. The parathyroid hormone is also called *parathormone* and plays a part in calcium and phosphate metabolism. Among other actions, it stimulates osteoclasts to break down bone, raising the calcium level in the blood. (Sofferman 2012)

2-3Related Structures

Recall that the neck can be subdivided into paired anterior and posterior triangles. The anterior triangles are formed in the midline by an imaginary line called the median line of the neck that transects the symphysis menti (mandibular symphysis), laterally by the medial border of sternocleidomastoid and superiorly by the inferior border of the mandible . The thyroid gland occupies the inferior part of both anterior triangles. (Sofferman 2012)

It is covered by the overlying skin and very little subcutaneous tissue. Beneath the skin is the superficial cervical fascia, which covers and blends with the aponeurosis of the platysma muscle . The investing cervical fascia covers the superficial muscles of the neck, while the pretracheal fascia invests the thyroid gland and other neck viscera. There are several neck muscles that course over the anterior surface of the thyroid gland. The sternothyroid forms the immediate anterior relation and more anteriorly lie the superior belly of the omohyoid muscles and sternohyoideus; while fibres of the anterior border of sternocleidomastoid course over the anteroinferior region of the gland. They sternohyoid muscle also wraps around the lateral convexity of the gland as well, thus limiting the superior poles of the thyroid gland from projecting on the thyrohyoid muscle. The superior poles of the gland also come into close proximity with the inferior pharyngeal constrictors. Additionally, it is separated from the lamina of the thyroid cartilage as well as the cricoids cartilage by the posterior part of the cricothyroid muscle. Medially, the gland is related with larynx and trachea and is fixed to the cricoids cartilage, along with the first two tracheal rings, by the suspensory ligament of Berry. The cricothyroid muscles and the inferior constrictors of the pharynx are the medial muscular relations. The external laryngeal nerve passes by the gland along this border as well. Both the recurrent laryngeal nerve and the trachea are postero-inferiorly related to the medial border of the thyroid gland. The carotid sheath can be found near the posterolateral border of the gland. The anterior branch of the superior, and the inferior, thyroid arteries are related to the anterior and posterior borders of the thyroid gland, respectively. Another important structure that has a posteroinferior relationship to the left lobe of the thyroid gland is the thoracic duct . Additionally, the parathyroid glands are often embedded in the superior and inferior extents of the gland as well. **(Sofferman 2012)**

2-4 Congenital and Developmental Anomalies of Thyroid Gland

Occasionally, rests of thyroid tissue may remain along the course of thyroglossal duct, giving rise to an additional thyroid lobe, the pyramidal lobe, attached to distal end of population). Persistence of thyroglossal duct results in formation of thyroglossal cyst, which clinically presents as midline neck swelling or lump, usually found at level of hyoid bone or thyroid cartilage. Ectopic thyroid gland develops most commonly at sublingual (midline at foramen cecum), suprahyoid or infrahyoid position. Ectopic thyroid tissue and the normal thyroid gland may or may not be present at normal position. Ectopic thyroid may be easily detected on CT and radionuclide scans. Congenital agenesis or hypoplasia (unilobar type or of isthmus) of the thyroid gland may occur due to developmental failure of all or part of thyroid gland. On, agenesis of isthmus is characterized by absence of isthmus with the lateral lobes positioned independently on either side of the trachea. thyroid gland may occur due to developmental failure of all or part of thyroid gland. On, agenesis of isthmus is characterized by absence of isthmus with the lateral lobes of trachea. **(Chaudhary and Bano 2016)**

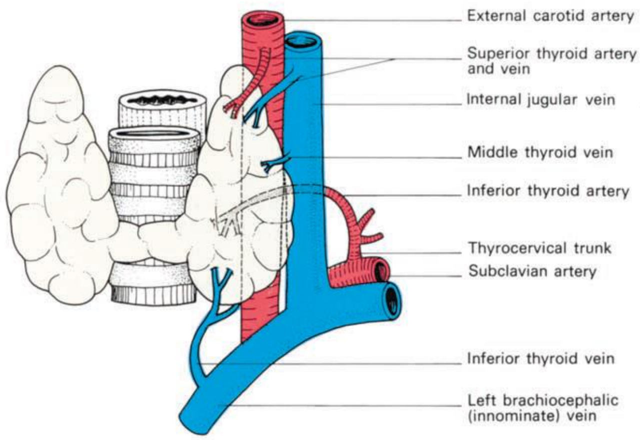


Fig (2-1) show Anatomy of thyroid gland and Blood vessels (Ellies 2006)

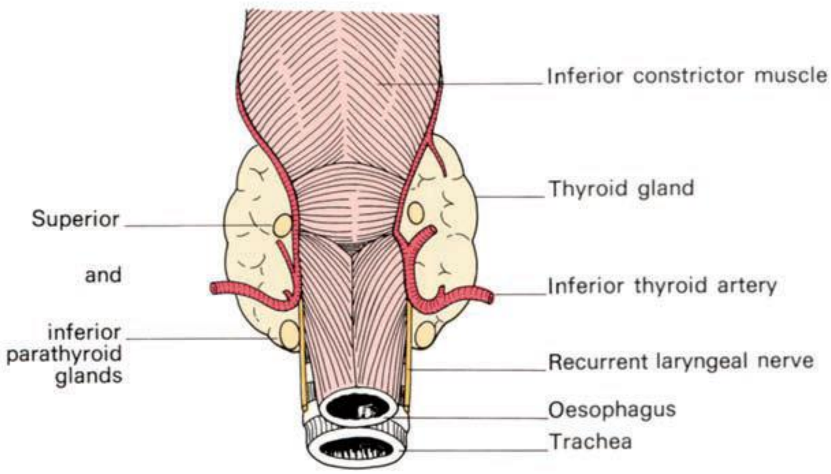


Fig (2-2) shows normal sites of the parathyroid glands (posterior aspect). (Ellies 2006)

2-2Physiology

2-2-1Thyroid Hormones

T3 and T4 are necessary for normal growth. Secretion and release of both hormones are regulated by the action of TSH from the hypothalamopituitary system. If, for instance, a decline in blood thyroxine level is registered in the hypothalamus, the latter liberates a releasing hormone (thyrotropin-releasing hormone, TRH), which in turn induces the liberation of TSH in the anterior pituitary. TSH stimulates the thyroid, which releases thyroxine into the bloodstream. In addition to the two hormones thyroxine and triiodothyronine, another hormone, calcitonin, is secreted in cells called *parafollicular cells*(C cells). Calcitonin reduces the level of calcium in the blood and promotes. (**Despopoulos 2004).**

In thyroid over activity (hyperthyroidism, Graves disease), cellular combustion increases (increased basal metabolism). This results in weight loss, raised body temperature, and acceleration of the heart rate. Often the eyeball protrudes from the orbit (exophthalmos), the pupils enlarge, and the condition may be accompanied by nervous excitability. In thyroid insufficiency (hypothyroidism), metabolism, growth, and mental activity are all slowed. In addition, the skin thickens and swells (myxodema). The commonest cause of hypothyroidism is iodine deficiency in the diet (or drinkingwater), which induces increased release of TSH from the pituitary gland. This causes the thyroid gland to become enlarged, a condition called *goiter* (*struma*). Congenital goiter results in dwarfism and cretinism. The thyroid gland contains spherical follicles (50–500 μmin diameter). Follicle cells synthesize the two iodine-containing thyroid hormones thyroxine (T4, tetraiodothyronine) and triiodothyronine (T3) (Radrigues 2004).

T3 and T4 are bound to the glycoprotein *thyroglobulin* (!B2) and stored in the colloid of the follicles (!A1, B1). The synthesis and release of T3/T4 is controlled by the *thyroliberin* (= *thyrotropin-releasing hormone*, TRH)—*thyrotropin* (TSH) *axis* (!A, and p. 270ff.). T3 and T4 influence physical growth, maturation and metabolism. The *parafollicular cells* (*C cells*) of the thyroid gland synthesize *calcitonin.* Thyroglobulin, a dimeric glycoprotein (660 kDa) is synthesized in the thyroid cells. TSH stimulates the transcription of the thyroglobulin gene. Thyroglobulin is stored in vesicles and released into the colloid by exocytosis Iodine uptake. The iodine needed for hormone synthesis is taken up from the bloodstream as iodide (I–). It enters thyroid cells through secondary active transport by the Na+-I– symport carrier (NIS) and is concentrated in the cell ca. 25 times as compared to the plasma (!B2) (Besser 2002).

Via cAMP, TSH increases the transport capacity of basolateral I– uptake up to 250 times. (**Despopoulos 2003).**

Other anions competitively inhibit I– uptake; e.g., ClO4 –, SCN– and NO2. Hormone synthesis. I– ions are continuously transported fromthe intracellular *I– pool* to the apical (colloidal) side of the cell by a I–/Cl– antiporter, called *pendrin*, which is stimulated by TSH. With the aid of *thyroid peroxidase* (TPO) and an H2O2 generator, they are oxidized to elementary I2 along the microvilli on the colloid side of the cell membrane. With the help of TPO, the I0 reacts with about 20 of the 144 tyrosyl residues of *thyroglobulin* (!C) (Butier 2001).

The phenol ring of the tyrosyl residue is thereby iodinated at the 3 and/or 5 position, yielding a protein chain containing either *diiodotyrosine (DIT)* residues and/or *monoiodotyrosine (MIT)* residues. These steps of synthesis are stimulated by TSH (via IP3) and inhibited by thiouracil, thiocyanate, glutathione, and other reducing substances. The structure of the thyroglobulin molecule allows the iodinated tyrosyl residues to react with each other in the thyrocolloid. The phenol ring of one DIT (or MIT) molecule links with another DIT molecule (ether bridges). The resulting thyroglobulin chain now contains tetraiodothyronine residues and (less) *triiodothyronine* residues (!C) (Burbach 2001).

These are the *storage* form of T4 and T3. TSH also stimulates T3 and T4 secretion. The iodinated thyroglobulin in thyrocolloid are reabsorbed by the cells via endocytosis (!B3, C). The endosomes fuse with primary lysosomes to form phagolysosomes in which thyroglobulin is hydrolyzed by proteases. This leads to the release of T3 and T4 (ca. 0.2 and 1–3 mol per mol of thyroglobulin, respectively). T3 and T4 are then secreted into the bloodstream (!B3). With the aid of *deiodase*, I– meanwhile is split from concomitantly released MIT and DIT and becomes reavailable for synthesis.

Control of T3/T4 secretion. TSH secretion by the anterior pituitary is stimulated by TRH, a hypothalamic tripeptide (!p. 280) and inhibited by somatostatin (SIH) (!A and p. 270). The effect of TRH is modified by T4 in the plasma. As observed with other target cells, the T4 taken up by the thyrotropic cells of the anterior pituitary is converted to T3 by *5□-deiodase*. T3 reduces the density of TRH receptors in the pituitary gland and inhibits TRH secretion by the hypothalamus (Cumminug 2003).

The secretion of TSH and consequently of T3 and T4 therefore decreases (*negative feedback circuit*). In neonates, cold seems to stimulate the release of TRH via neuronal pathways (thermoregulation) (Dattanic 2004).

TSH is a heterodimer (26 kDa) consisting of an ! subunit (identical to that of LH and FSH) and a " subunit. *TSH controls all thyroid gland functions*, including the uptake of I–, the synthesis and secretion of T3 and T4 (!A-C), the blood flow and growth of the thyroid gland. Goiter (struma) is characterized by diffuse or nodular enlargement of the thyroid gland. Diffuse goiter can occur due to an iodine deficiency, resulting in T3/T4 deficits that ultimately lead to increased secretion of TSH (Dunn 2004).

Chronic elevation of TSH leads to the proliferation of follicle cells, resulting in goiter development (*hyperplastic goiter*). This prompts an increase in T3/T4 synthesis, which sometimes normalizes the plasma concentrations of T3/T4 (*euthyroid goiter*). This type of goiter often persists even after the iodide deficiency is rectified. (**Guyton 2006)**

Hypothyroidism occurs when TSH-driven thyroid enlargement is no longer able to compensate for the T3/T4 deficiency (*hypothyroid goiter*). This type of goiter can also occur due to a congenital disturbance of T3/T4 synthesis (see below) or thyroid inflammation. Hyperthyroidism occurs when a thyroid tumor (*hot node*) or diffuse struma (e.g., in *Grave's disease*) results in the overproduction of T3/T4, independent of TSH. In the latter case, an autoantibody against the TSH receptor binds to the TSH receptor. Its effectsmimic those of TSH, i.e., it stimulates T3/T4 synthesis and secretion.

T3/T4 transport. T3 and T4 occur at a ratio of 1 : 40 in the plasma, where !99% of them (mainly T4) are bound to plasma proteins: *thyroxine- binding globulin* (TBG), thyroxine-binding prealbumin (TBPA), and *serum albumin*. TBG transports two-thirds of the T4 in the blood, while TBPA and serum albumin transport the rest. Less than 0.3% of the total T3/T4 in blood occurs in an unbound (free) form, although only the unbound molecules have an effect on the target cells (Edmondson 2003).

Certain drugs split T3 and T4 from protein bonds, resulting in increased plasma concentrations of the free hormones. Potency of T3/T4. T3 is 3–8 times more potent than T4 and acts more rapidly (half-life of T3 is 1 day, that of T4 7 days). Only ca. 20% of all circulating T3 originate from the thyroid; the other 80% are produced by the liver, kidneys, and other target cells that cleave iodide from T4. (**Guyton 2006)**

The actions of T3/T4 are numerous and mainly involve the *intermediate metabolism*. The thyroid hormones increase the number of *mitochondria* and its cristae, increase Na+-K+- ATPase activity and modulate the cholesterol metabolism. This results in an increase in *energy turnover* and a corresponding rise in O2 consumption and heat production (Freeman 2000).

T3 also specifically stimulates heat production by increasing the expression of the uncoupling protein *thermogenin* in brown fat. T3 also influences the efficacy of other hormones. Insulin, glucagon, GH and epinephrine lose their energy turnover-increasing effect in *hypothyroidism*, whereas the sensitivity to epinephrine increases (heart rate increases, etc.) in *hyperthyroidism*. T3 is thought to increase ىthe density of !-adrenoceptors. T3 also stimulates *growth* and *maturation*, especially of the brain and bones. Cretinism occurs due to neonatal T3/T4 deficiencies and is marked by growth and maturation disorders (dwarfism, delayed sexual development, etc.) and central nervous disorders (intelligence deficits, seizures, etc.) (Gimle 2001).

The administration of thyroid hormones in the first six months of life can prevent or reduce some of these abnormalities. Iodine metabolism (!D). Iodine circulates in the blood as either inorganic I– (2–10 µg/L), organic non-hormonal iodine (traces) and protein-bound iodine (PBI) within T3 and T4 (35–80 µg iodine/L). The average daily requirement of iodine is ca. 150 µg; larger quantities are required in fever and hyperthyroidism (ca. 250–500 µg/day). Iodine excreted from the body must be replaced by the diet (!D). Sea salt, seafood, and cereals grown in iodine-rich soil are rich in iodine. Both of these hormones profoundly increase the metabolic rate of the body. Complete lack of thyroid secretion usually causes the basal metabolic rate to fall 40 to 50 per cent below normal, and extreme excesses of thyroid secretion can increase the basal metabolic rate to 60 to 100 per cent above normal. Thyroid secretion is controlled primarily by *thyroid-stimulating hormone (TSH)* secreted by the anterior pituitary gland. (**Guyton 2006).**

2-2-1Metabolic Hormones

About 93 per cent of the metabolically active hormones secreted by the thyroid gland is *thyroxine*, and 7 per cent *triiodothyronine*. However, almost all the thyroxine is eventually converted to triiodothyronine in the tissues, so that both are functionally important. The functions of these two hormones are qualitatively the same, but they differ in rapidity and intensity of action. Triiodothyronine is about four times as potent as thyroxin, but it is present in the blood in much smaller quantities and persists for a much shorter time than does thyroxin. (Despopoulos 2003).

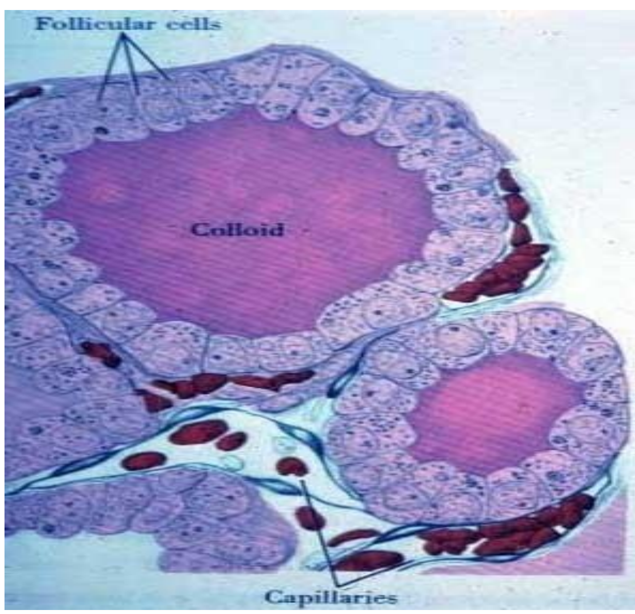


Fig 2-3 shows the thyroid tissue (Guyton 2006).

2-3 Normal measurement of the thyroid gland:

The normal thyroid gland consists of two lobes and a bridging isthmus. Thyroid size, shape and volume varies with age and sex. Normal thyroid lobe dimensions are: 18-20 mm longitudinal and 8-9 mm antero-posterior (AP) diameter in newborn; 25 mm longitudinal and 12-15 mm AP diameter at one year age; and 40-60 mm longitudinal and 13-18 mm AP diameter in adult population. The limits of normal thyroid volume (excluding isthmus, unless its thickness is >3 mm) are 10-15 ml for females and 12-18 ml for males. The relationships with surrounding structures are sterno-cleido-mastoid and strap muscles anteriorly; trachea/esophagus and longus colli muscles posteriorly; and common carotid arteries and jugular veins bilaterally (**Chaudhary, Bano 2016).**

2-4Ultrasound imaging

2-4-1History of Thyroid Ultrasound:

Application of ultrasound for thyroid imaging began in the late 1960s. In July 1967 Fujimoto et al. reported data on 184 patients studied with a B-mode ultrasound "tomogram" utilizing a water bath (8). The authors reported that no internal echoes were generated by the thyroid in patients with no known thyroid dysfunction and nonpalpable thyroid glands. They described four basic patterns generated by palpably abnormal thyroid tissue. The type 1 pattern was called "cystic" due to the virtual absence of echoes within the structure, and negligible attenuation of the sound waves passing through the lesion. Type 2 was labeled "sparsely spotted," showing only a

In December 1971 Manfred Blum published a series of A-mode ultrasounds of thyroid nodules. Additional publications in the early 1970s further confirmed the capacity for both A-mode and B-mode ultrasound to differentiate solid from cystic lesions, but consistently demonstrated that ultrasound was unable to distinguish malignant from benign solid lesions with acceptable accuracy. During the 1980's Doppler ultrasound was developed, allowing detection of flow in blood vessels, the Doppler pattern of blood flow within thyroid nodules has an important role in assessing the likelihood of malignancy. Doppler imaging may also demonstrate the increased blood flow characteristic of Graves' disease, and may be useful in distinguishing between Graves' disease and thyroiditis, especially in pregnant patients or patients with amiodaroneinduced hyperthyroidism. Recent technological advancements include intravenous sonographic contrast agents, three-dimensional ultrasound imaging and elastography. Intravenous sonographic contrast agents are available in Europe, but remain experimental in the United States. At the present time, however, 3D ultrasound technology does not have a demonstrable role in thyroid imaging. Elastography is a new technique in which the compressibility of a nodule is assessed by ultrasound as external pressure is applied. The thyroid is well suited to ultrasound study because of its superficial location, vascularity, size and echogenicity. In addition, the thyroid has a very high incidence of nodular disease, the vast majority benign (Chaudhary 2016).

Most structural abnormalities of the thyroid need evaluation and monitoring, but not intervention. Thus, the thyroid was among the first organs to be well studied by ultrasound. The first reports of thyroid ultrasound appeared in the late 1960s. Between 1965 and 1970 there were seven articles published specific to thyroid ultrasound. In the last five years there have been over 1,300 published. Thyroid ultrasound has undergone a dramatic transformation from the cryptic deflections on an oscilloscope produced in A-mode scanning, to barely recognizable B-mode images, followed by initial low resolution gray scale, and now modern high resolution images. Recent advances in technology, including harmonic imaging, contrast studies, and three-dimensional reconstruction, have furthered the field. The first diagnostic application of ultrasound occurred in 1942. In a paper entitled "Hyperphonagraphy of the Brain," Karl Theodore Dussic reported localization of the cerebral ventricles using ultrasound. Unlike the current reflective technique, his system relied on the transmission of sound waves, placing a sound source on one side of the head, with a receiver on the other side. A pulse was transmitted, with the detected signal purportedly able to show the location of midline structures (Zhang 2010).

2-4-3Normal Ultrasound appearance:

In order to recognize neck pathology, it is important to be familiar with the anatomy and ultrasound appearance of the normal neck. A normal healthy thyroid lobe is pear-shaped in the transverse view and resembles "ground glass" in appearance on the ultrasound monitor. It is bordered anteriorly by the strap muscles (sternohyoid, sternothyroid and omohyoid). Lateral to the thyroid lie the large sternocleiodomastoid muscle, the carotid artery and the internal jugular vein. The *longus colli* muscle is posterior and the trachea is medial to the thyroid lobe. The parathyroid glands are posterior to the thyroid and usually not seen unless they are enlarged. The esophagus can also be seen protruding from behind the tracheal shadow posterior to the left lobe. Real-time ultrasound shows the vessels pulsating, and peristalsis can be seen in the esophagus when the patient is asked to swallow. Very rarely, the esophagus will be seen on the right. Measurement of the volume of the thyroid gland is sometimes difficult using ultrasound because most modern small parts transducers have a footpad of only 4 cm or less, and the normal thyroid lobe is over 4 cm long. If the lobe is longer than the transducer, a “split screen technique” can be used to . (Solbiati 2001)

Normal appearing thyroid in transverse view. Thyroid is homogeneous and slightly hyperechoic. The lobes are bordered anteriorly by the strap muscles (SM), posteriorly by the *longus colli* muscle (LC), medially by the trachea, and laterally by the sternocleidomastoid muscle (SCM), carotid artery and jugular vein. A portion of the esophagus (ESO) protrudes behind the tracheal shadow against the medial border of the left lobe measure the length of the lobe. Transducers with a footpad of 6cm or more are used when thyroid volume is important, such as epidemiological studies screening for endemic goiter. The normal thyroid gland is 2 cm or less in both the transverse dimension and depth, and is 4.5–5.5 cm in length. In clinical practice in North America, routine measurement of the volume of the entire gland is not always necessary; however, measuring the volume of thyroid nodules is important and is done in the same manner. Measurement of the thyroid (or a nodule) involves three measurements, the width, depth and length. The volume can then be calculated using the formula for a prolate ellipse: Volume = $\pi/6$ ($W \times D \times L$). The width (W) of a thyroid lobe is measured from an imaginary vertical line drawn along the lateral edge of the trachea to the most lateral border of the thyroid gland. The depth (D) is measured on the same screen and is the maximum anterior-posterior distance in the middle third of the lobe. The length (L) is measured in the longitudinal view and is the maximum distance from the most cranial to the most caudal part of the lobe. Most ultrasound equipment has an onboard computer to calculate the volume of each lobe (or nodule) from the three measurements. After calculating the volumes of each lobe, they are added together for the total volume of the gland (Levine 2004).

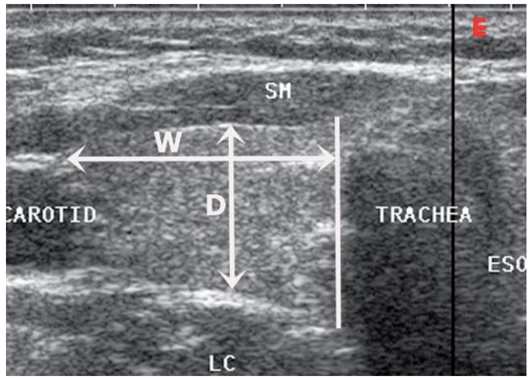


Fig (2-4) Measurement of thyroid lobe. The width (W) is measured from an imaginary line drawn along the lateral edge of the trachea to the lateral border of the thyroid. The depth (D) is measured on the same view and is the maximum anterior-posterior distance in the middle third of the lobe (Levine 2004).

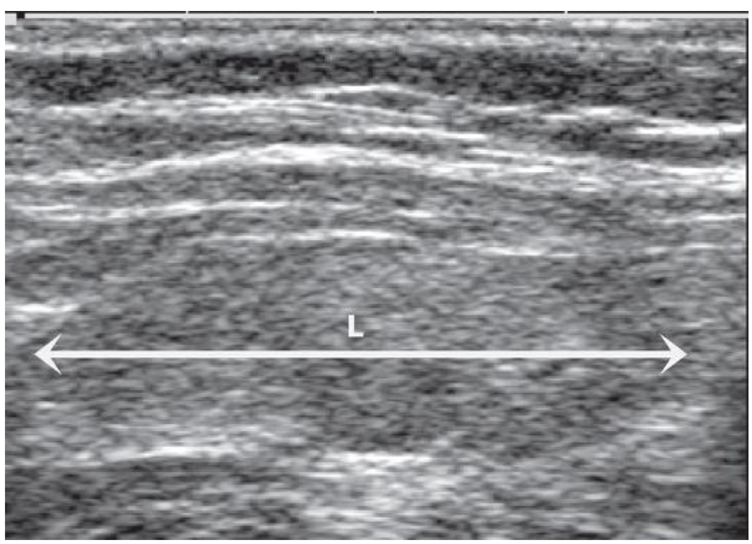


Fig. (2-5). In the longitudinal view of the thyroid, the length (L) is measured from the cranial to the caudal ends of the lobe (Levine 2004).

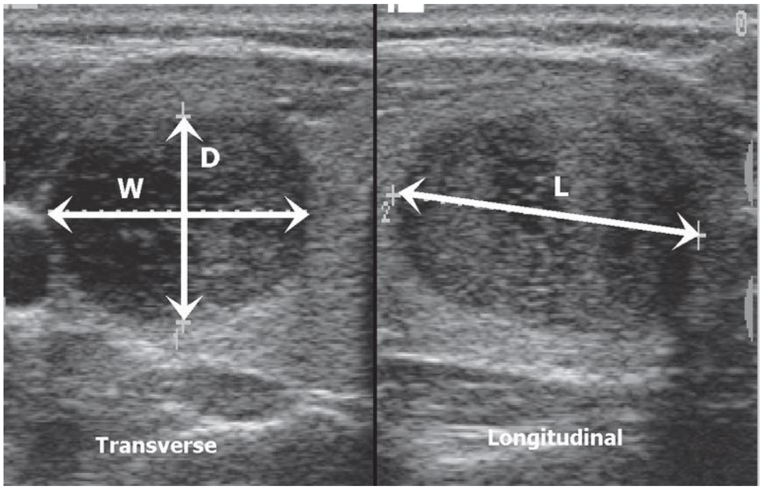


FIG. 2-6. Measure the volume of a thyroid nodule using the same formula used to calculate the volume of a thyroid lobe: Volume = □/6 (W × D × L) (Levine 2004)

Fig. 2-7. From L to R demonstrates different footprint size, lineararray transducers with the transducer on the right demonstrating a smaller, curvilinear array transducer (Gharib 2016)

2-4-3Ultrasound Physics

Sound is transmitted as mechanical energy, in contrast to light, which is transmitted as electromagnetic energy. Unlike electromagnetic waves, sound waves require a propagating medium. Light is capable of traveling through a vacuum, but sound will not transmit through a vacuum. The qualities of the transmitting medium directly affect how sound is propagated. Materials have different speeds of sound transmission. Speed of sound is constant for a specific material and does not vary with sound frequency, *Acoustic impedance* is the inverse of the capacity of a material to transmit sound. Acoustic impedance of a material depends on its density, stiffness and speed of sound. When sound travels through a material and encounters a change in acoustic impedance a portion of the sound energy will be reflected, and the remainder will be transmitted. The amount reflected is proportionate to the degree of mismatch of acoustic impedance. Sound waves propagate by compression and rarefaction of molecules in space. Molecules of the transmitting medium vibrate around their resting position and transfer their energy to neighboring molecules. Sound waves carry energy rather than matter through space. (Levine 2004).

As shown in, sound waves propagate in a longitudinal direction, but are typically represented by a sine wave Diagnostic ultrasound uses pulsed waves, allowing for an interval of sound transmission, followed by an interval during which reflected sounds are received and analyzed. Typically three cycles of sound are transmitted as a pulse. The spatial pulse length is the length in space that three cycles fill. Spatial pulse length is one of the determinants of resolution. Since higher frequencies have a smaller pulse length, higher frequencies are associated with improved resolution. (Zhang 2010)

As illustrated in Fig. 2.3, at a frequency of 15 MHz the wavelength in biological tissues is approximately 0.1 mm, allowing an axial resolution of 0.15 mm. As mentioned above, the *speed of sound* is constant for a given material or biological tissue. It is not affected by frequency or wavelength. It increases with stiffness and decreases with density of the material. As seen in, common biologic tissues have different propagation velocities. Bone, as a very dense and stiff tissue, has a high propagation velocity of 4,080 meters per second. Fat tissue, with low stiffness and low density, has a relatively low speed of sound of 1,450 m per second. Most soft tissues have a speed of sound near 1,540 m per second. Muscle, liver and thyroid have a slightly faster speed of sound. By convention, all ultrasound equipment uses an average speed of 1,540 meters per second (Levine 2004). .

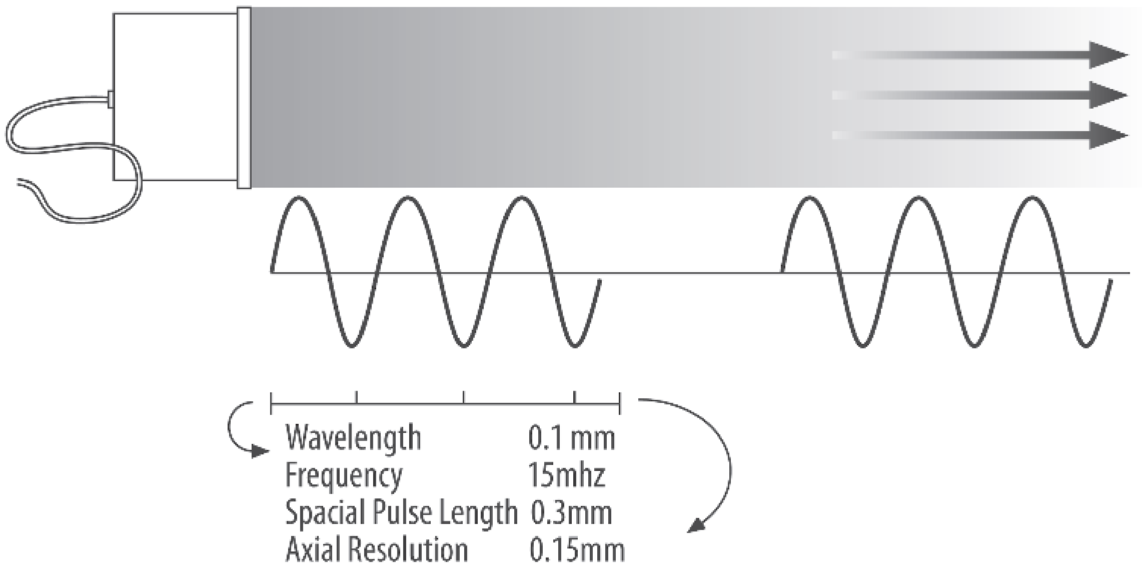
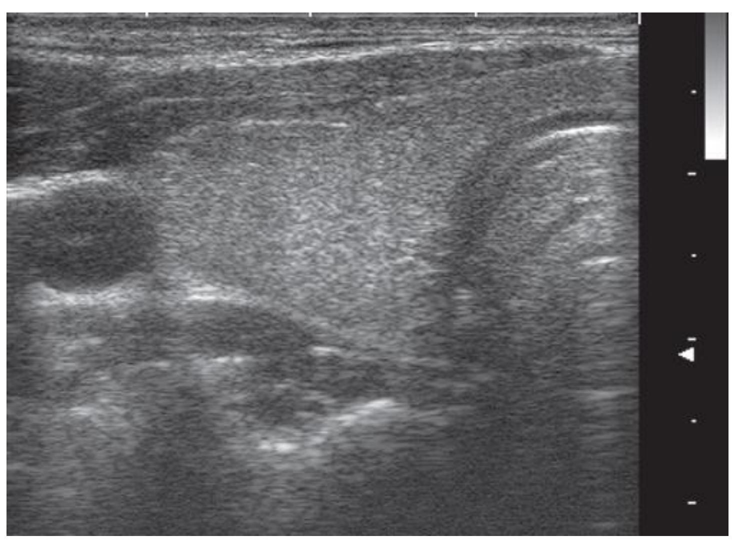


FIG. 2.8. Diagnostic ultrasound uses pulsed waves, allowing for an interval of sound transmission, followed by an interval during which reflected sounds are received and analyzed. Typically three cycles of sound are transmitted as a pulse Librarians (2004)



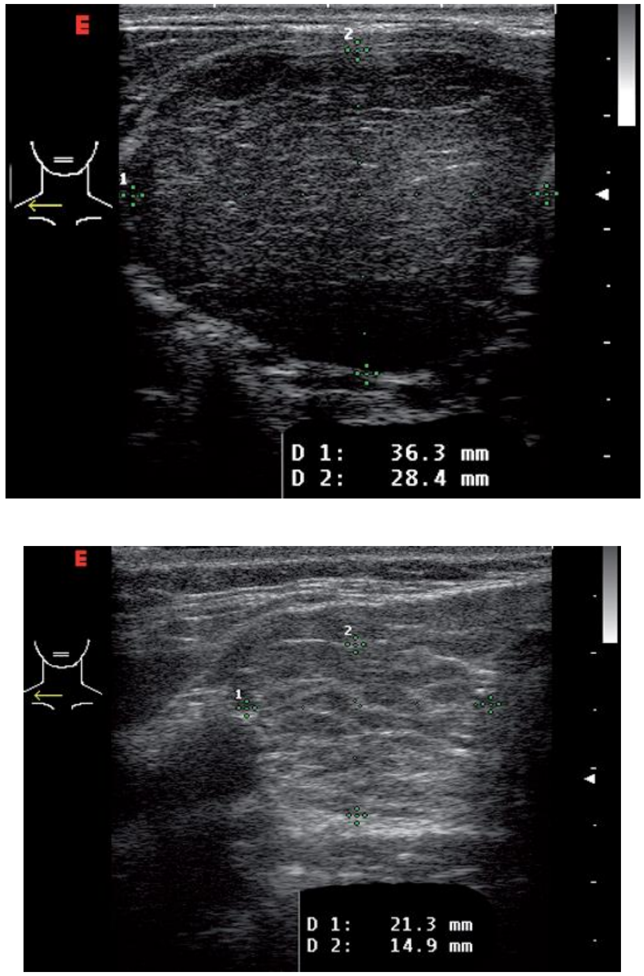


Fig. 2.9. Most biological tissues have varying degrees of inhomogeneity. Connective tissue, blood vessels, and cellular structure all provided mismatches of acoustic impedance that lead to the generation of characteristic ultrasonography patterns.

Librarians (2004)

2-4-4Doppler Ultrasound:

For most thyroid imaging, color-flow Doppler and power Doppler are used. In color-flow Doppler a unique color (or brightness) is assigned to an individual frequency. Typically a greater frequency shift (corresponding to a higher velocity) is assigned a brighter color. Analysis of the color-flow image gives a graphic illustration of the direction and speed of blood flow within soft tissue. In contrast, power Doppler considers all frequency shifts to be equivalent, integrating the total amount of motion detected. The assigned color represents the total amount of flow present, independent of the velocity. The color image, therefore, is indicative of the total amount of flow present, without information regarding velocity. Color-flow Doppler provides information regarding both direction and velocity, and is more useful in vascular studies. In contrast, power Doppler does not provide information regarding velocity. Chaudhary and Bano: 2013

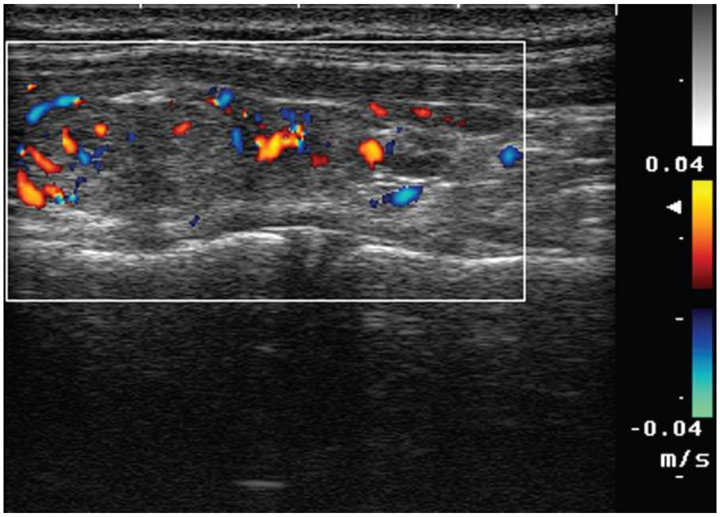


Fig 2-10. Color Doppler. In color-flow Doppler a unique color is assigned to an individual frequency. Typically a greater frequency shift (corresponding to a higher velocity) is assigned brighter color. Chaudhary and Bano: 2013

2-4-5Ultrasound Technique:

Patients are usually scanned in the supine position with the neck mildly hyperextended by an “oatmeal” pillow. Both lobes are scanned individually in the transverse and in the longitudinal planes. Any specific abnormalities should be studied in both planes by rotating the transducer 90 degrees over the area of concern. Remember that an ultrasound exam of the thyroid should always include the entire neck, looking for abnormal lymph nodes, enlarged parathyroid glands and abnormal masses. In order to recognize neck pathology, it is important to be familiar with the anatomy and ultrasound appearance of the normal neck. A normal healthy thyroid lobe is pear-shaped in the transverse view and resembles “ground glass” in appearance on the ultrasound monitor. It is bordered anteriorly by the strap muscles (sternohyoid, sternothyroid and omohyoid). Lateral to the thyroid lie the large sternocleiodomastoid muscle, the carotid artery and the internal jugular vein. The *longus colli* muscle is posterior and the trachea is medial to the thyroid lobe. The parathyroid glands are posterior to the thyroid and usually not seen unless they are enlarged. The esophagus can also be seen protruding from behind the tracheal shadow posterior to the left lobe. Real-time ultrasound shows the vessels pulsating, and peristalsis can be seen in the esophagus when the patient is asked to swallow. (Zhang et al 2010)

Very rarely, the esophagus will be seen on the right. Measurement of the volume of the thyroid gland is sometimes difficult using ultrasound because most modern small parts transducers have a footpad of only 4 cm or less, and the normal thyroid lobe is over 4 cm long. If the lobe is longer than the transducer, a “split screen technique” can be used to measure the length of the lobe. Transducers with a footpad of 6cm or more are used when thyroid volume is important, such as epidemiological studies screening for endemic goiter. The normal thyroid gland is 2 cm or less in both the transverse dimension and depth, and is 4.5–5.5 cm in length. In clinical practice in North America, routine measurement of the volume of the entire gland is not always necessary; however, measuring the volume of thyroid nodules is important and is done in the same manner. Measurement of the thyroid (or a nodule) involves three measurements: the width, depth and length. The volume can then be calculated using the formula for a prolate ellipse as volume = □/6 (W × D × L). The width (W) of a thyroid lobe is measured from an imaginary vertical line drawn along the lateral edge of the trachea to the most lateral border of the thyroid gland. The depth (D) is measured on the same screen and is the maximum anterior-posterior distance in the middle third of the lobe. The length (L) is measured in the longitudinal view and is the maximum distance from the most cranial to the most caudal part of the lobe. Most ultrasound equipment has an onboard computer to calculate the volume of each lobe (or nodule) from the three measurements. After calculating the volumes of each lobe, they are added together for the total volume of the gland. The isthmus is ignored unless a noduleis present. (**Zhang et al 2010)**

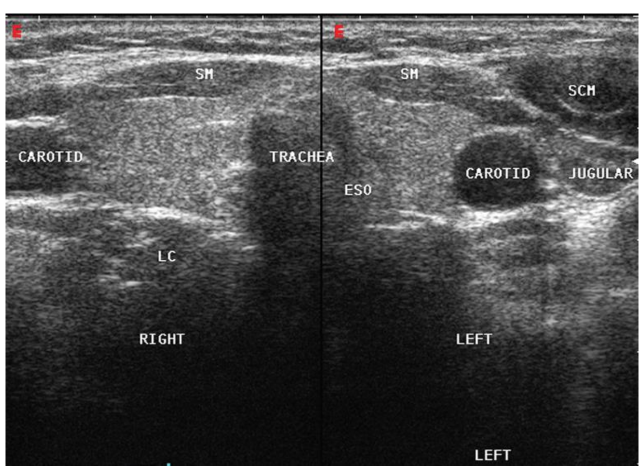


Fig (2-11)Normal appearing thyroid in transverse view. Thyroid is homogeneous and slightly hyperechoic. The lobes are bordered anteriorly by the strap muscles (SM), posteriorly by the *longus colli* muscle (LC), medially by the trachea, and laterally by the sternocleidomastoid muscle (SCM), carotid artery and jugular vein. A portion of the esophagus (ESO) protrudes behind the tracheal shadow against the medial border of the left lobe (Zhang et al 2010)

2-4-6 Advanced Ultrasound Techniques in Thyroid Imaging

2-4-6-1Ultrasound elastography

Is a dynamic technique that estimates stiffness of tissues by measuring the degree of distortion under external pressure. Thyroid gland elastography is used to study hardness/elasticity of the thyroid nodule to differentiate malignant from benign lesions. A benign nodule is softer and deforms more easily, whereas the malignant nodule is harder and deforms less when compressed by ultrasound probe. The elastography technique utilizes external compression to differentiate malignant thyroid nodules from benign lesions. It determines the amount of tissue displacement at various depths, by assessing the ultrasound signals reflected from the tissues before and after compression. Dedicated software then provides an accurate measurement of tissue distortion and displays it visually as an elastography image. The elastographic image (elastogram) displayed over the B-mode image in a color scale, indicates local tissue elasticity as very soft in blue color for tissue with greatest elastic strain and very hard in red color for tissue with no strain. Real-time shear elastography is a latest technique; that characterizes and quantifies tissue stiffness better than conventional elastography **(Zhang et al 2010).**

2-4-6-2Contrast enhanced ultrasound (CE-US):

is a newly developed technique that helps in characterizing a thyroid nodule. On CE-US, enhancement patterns are different in benign and malignant lesions. Ring enhancement is predictive of benign lesions, whereas heterogeneous enhancement is helpful for detecting malignant lesions. However, overlapping findings seem to limit the potential of this technique in the characterization of thyroid nodules. Use of specific contrast (e.g. Sono Vue) and pulse inversion harmonic imaging further improves the efficacy of ultrasound in diagnosing a malignant thyroid nodule (**Chaudhary and Bano 2006).**

2-5Perivous studies

Nick et al (2011) determine the thyroid lobes in thyroid ultrasound image using MATLAB. The thyroid measurement and recognition system is very useful in medical field such as early thyroid cancer diagnostic. The thyroid ultrasound image will undergo the image enhancement method that is contrast enhancement histogram equalization to suppress speckle. Then the enhancement image will undergo local region-based active contour to segment the thyroid region. The thyroid region will be segmented into two parts that are right and left with the active contour method separately. This is due to the thyroid that divided into two lobes that is right lobe and left lobe. Thyroid ultrasound image transverse view will be used in this project. Therefore the measurement involve is only width, depth and area of thyroid region. The result of measurement involve of thyroid is successful calculated in pixel unit. The measurement is converted in centimeter (cm) unit. The proposed method can be used to enhance the image and segmentation of the thyroid lobe. It shows that from five samples, different people have different size of thyroid especially in measurement of width, depth and area.

Michael (2005) This study was undertaken to investigate the inter-observer reproducibility of 2D and 3D ultrasound in the measurement of thyroid gland volume. The symmetry of thyroid lobes in healthy subjects was also investigated. The volume of the left and right lobes of the thyroid gland was measured in 20 healthy subjects (10 men and 10 women) using 2D and 3D ultrasound. On 2D ultrasound, the thyroid lobe volume was calculated by ellipsoidequation(volume = $\pi/6 \times$ craniocaudal $\times$ mediolateral $\times$ anteroposter ior dimensions), whereas 3D ultrasound volumetric measurements were performed with a 3D add-on system. In each subject, the thyroid gland was scanned by two operators to investigate inter-observer variability.

This study found that there was a moderate agreement between 2D and 3D ultrasound in the measurement of thyroid volume ($r = 0.77$). 3D ultrasound (90%) had a higher inter-observer reproducibility than 2D ultrasound (85%) in the measurements. About 74% of healthy subjects had the right thyroid lobe larger than the left lobe. The study conclude that 3D ultrasound is useful in the measurement of thyroid volume with a higher reproducibility than 2D ultrasound. Asymmetry of thyroid lobes was noted in healthy subjects.

Reiners (2004) The aim of this study was to estimate accuracy, intraobserver variability, and repeatability of thyroid volume measurement by ultrasound using conventional two-dimensional ellipsoid model (2D US) and manual planimetry of three-dimensional images (3D US). The sonographic images of 47 children with thyroid nodular pathology who were referred for thyroid surgery in Belarus were evaluated prospectively. Two-dimensional images were acquired using the ultrasound scanner with 7.5-MHz linear probe. Three-dimensional data sets were created using three-dimensional system, Free Scan. For each patient thyroid volume was measured three times using both two- and three-dimensional methods. Results of volume estimation were then compared to the volume of thyroid gland determined after surgery. Standardized difference between thyroid volume estimated by ultrasound and surgery (mean ± standard deviation (SD), %) for 3D and 2D US methods was 1.8 ± 5.2% and 3.2 ± 15.3%, respectively. The 3D US has lower intraobserver variability (3.4%) and higher repeatability (96.5%) than 2D US with 14.4% variability and 84.8% repeatability ($p < 0.001$). In conclusion, three-dimensional sonography allows accurate measurement of thyroid volume with low intra observer variability and high repeatability.

Shabana (2006) assessment of thyroid volume with sonography (formula of an ellipsoid), a correction factor is used. Whereas previously 0.524 was used, the World Health Organization has recently changed (after the first review) this correction factor to 0.479. We compare volume measurement of the thyroid using different correction factors to automated volume measurement using MDCT, and we define an optimal correction factor in thyroid volume assessment. This study conclude that the acceptable correction factors are situated in the range of 0.494-0.554. We propose a correction factor of 0.529 when using the ellipsoid formula

Chapter Three

Materials and Method

3-1Materials:

3-1-1 Subject:

This descriptive, cross-sectional study where the data were collected prospectively. This study consist of normal 50 female aged between 12-50 years old, in white Nile State , any subject had abnormalities in thyroid tissues or thyroid hormone and any congenital anomalies in thyroid and neck are excluded.

3-1-2 Machine:

The study done in Rabk Hospital as the Capital of White Nile State using machine made in China and using (7-15) linear probe which had highest frequency

3-2 Method

3-2-1 Technique:

There is no specific preparation done except that the area must be free from overlapping materials. All patient scanning in supine position with pillow under shoulder and hyperextended of the neck slightly to allow head to rest in examination table, and scan whole thyroid, start the scan from sternal notch and then scan each lobe separately. The scan start by placing transducer over the neck and then angled the beam as necessary and adjust the Time Gain Compensation (TGC) with adequate sensitivity setting to allow uniform acoustic pattern, thus obtain the best image of thyroid gland.

3-2-2 Image measurement and presentations

The measurement don for each lobe in three plane length, wide and depth (L,W,D) and the

3-2-3 Statistic method

The data analysis by frequency table and using computer program, Statistical Package for Social Science (SPSS)

2-3-4 Ethical considerations

Hospital and all patient had permission for this scan.

Chapter Four

Results

Table (4-1) illustrate patient age

Age Group	Frequency	Percent
12-18	8	14.8
19-30	26	48.1
31-40	13	24.1
41-50	7	13.0
Total	54	100.0

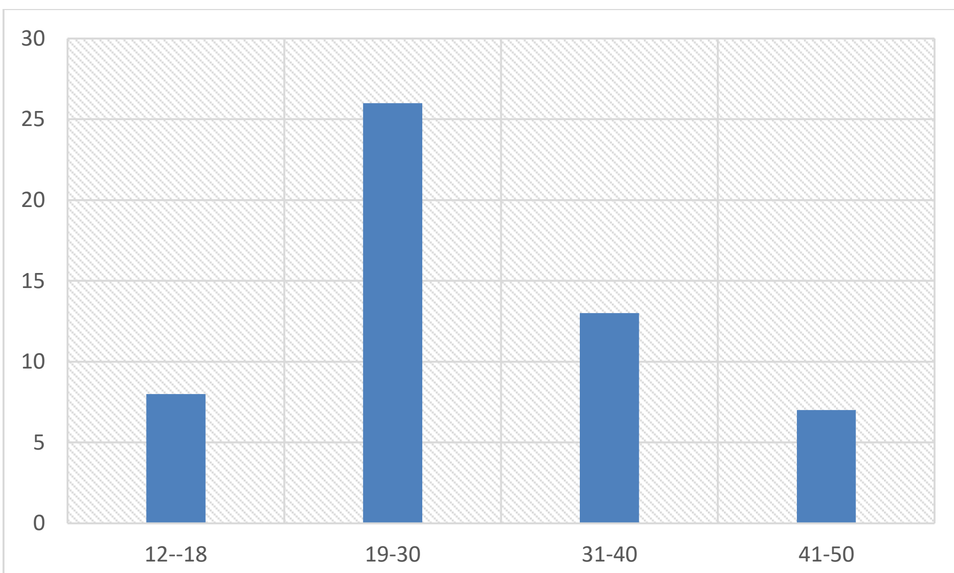


Figure (4-1) illustrate patients age group

Table (4-2) illustrate thyroid volume

Total Volume Group	Frequency	Percent
3-5	16	29.6
5.1-7	25	46.3
7.1-9	5	9.3
9.1-11	8	14.8
Total	54	100.0

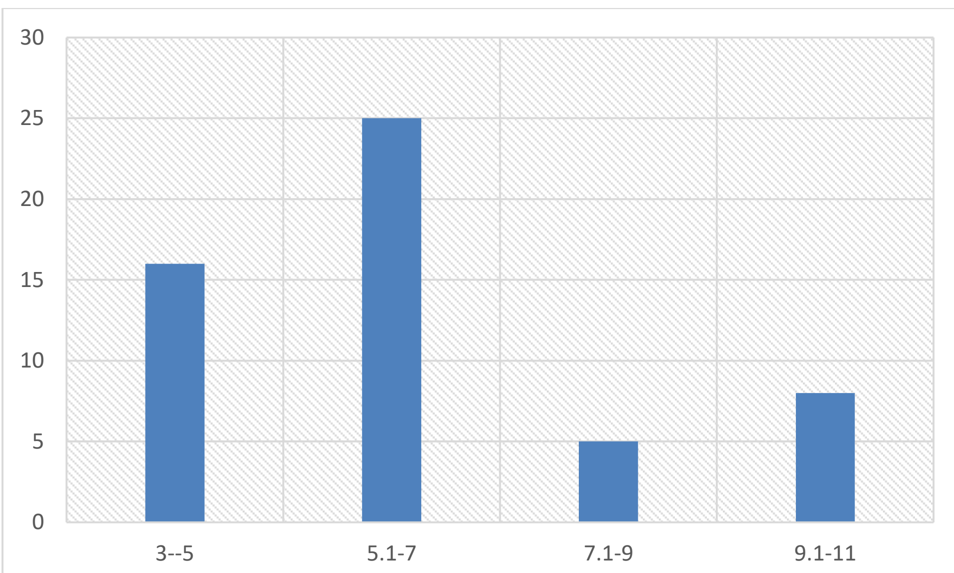


Table (4-2) illustrate thyroid volume

Table (4-3) illustrate the correlations between age and right and left lobe

	Mean	STD	Min	Max
Age	27.78	8.94	12	48
Volume R.L	3.55	0.95	2.2	5.5
Volume L.L	2.57	0.92	1.2	4.5
Total Volume	6.12	1.84	3.4	10

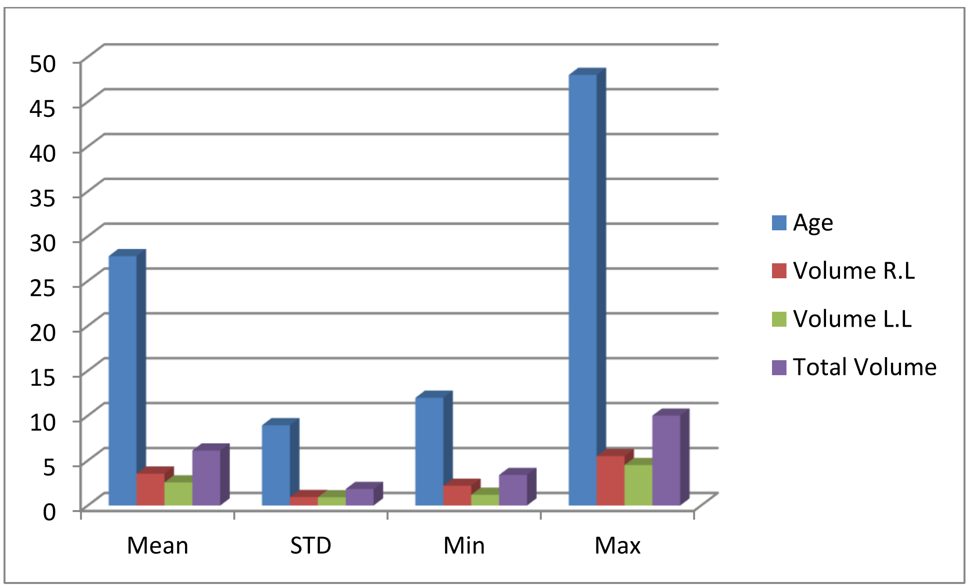


Figure (4-3) illustrate the correlations between age and right and left lobe

Table (4-4) illustrate correlations between Age Group and Total Volume of thyroid

Age Group	Total Volume Group				Total
	3-5	5.1-7	7.1-9	9.1-11	
12-18	6	2	0	0	8
19-30	10	15	1	0	26
31-40	0	8	4	1	13
41-50	0	0	0	7	7
Total	16	25	5	8	54

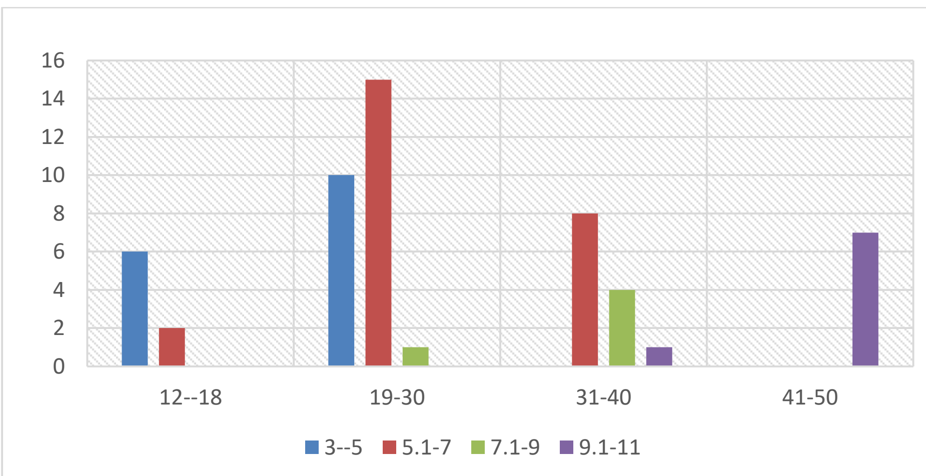


Figure (4-4) illustrate correlations between Age Group and Total Volume of thyroid

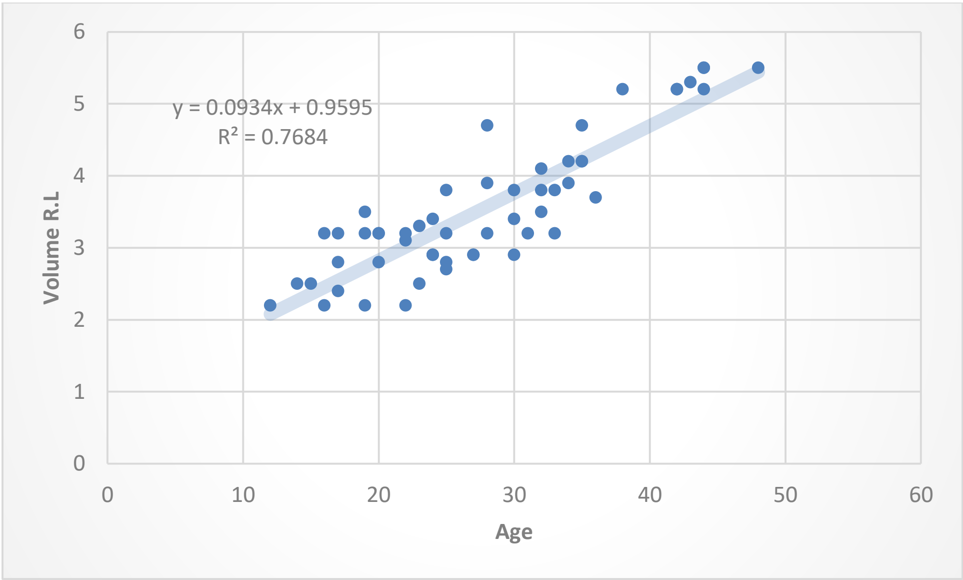


Figure (4-5) Scatter plot illustrate correlations between right lobe and patients age

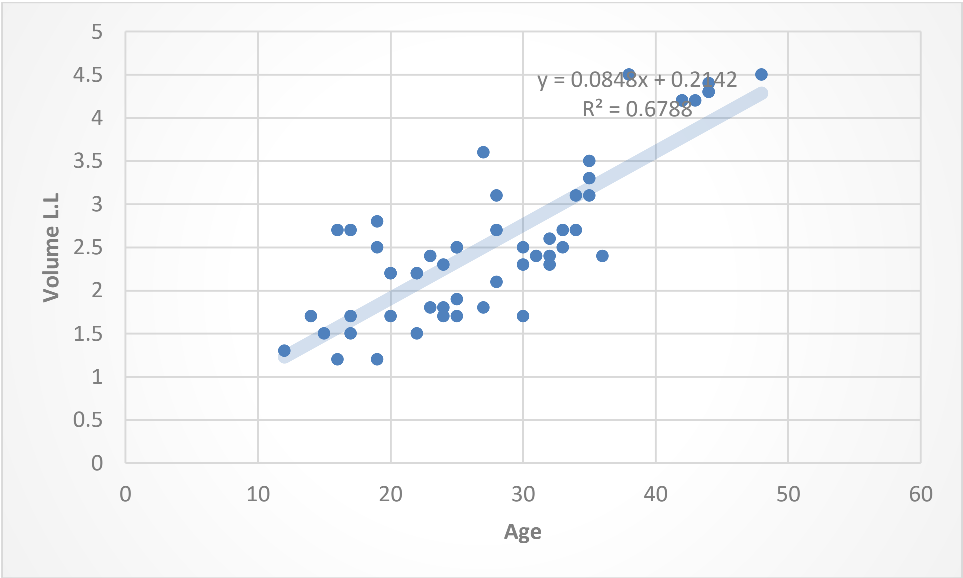


Figure (4-6) Scatter plot illustrate correlations between left lobe and patients age

Chapter five

Discussion, Conclusion, and Recommendations

5-1 Discussion:

Thyroid ultrasound scan was performed by ultrasound machine with 7-15 MHz linear transducer, Sonographic classification based on Sonographic features and measurement, Sonographic features include echogenicity and echo-textures, margin. The result of this study that shows the patient aged bet 12-50 years old that the main affected age between 19-30 the mean of aged 27.78 in Table 4-1 .

The affected thyroid volume was 5.1-7 mm in 25 individual percentage 46.3%, and maximum volume of this study was 9.1-11mm in 8 individual percentage 14.8%, and minim volume of the thyroid in this study was 3.5 mm in 16 individual percentage 29.6%. Table 4-2 shows that.

The correlation between aged group and right and left lobe of thyroid gland, the maximum aged was 48 and right lobe maximum volume was 5.5 mm and right lobe maximum volume was 4.5 mm so that maximum thyroid volume was 10mm, standard deviations (STD) of aged was 8.94 and STD of right lobe was 0.95 and left lobe STD was 0.92. The mean of age was 27.78, mean of right lobe was 3.55, and mean of left lobe was 2.27 the total mean of thyroid was 6.12. The affected thyroid volume was 5.1-7 mm in affected aged group 19-30 years old, this measurement conclude that right lobe volume is more than left one this agree with Michael 2005, Table 4-3 show this result).

Scatter plot (4-5) shows the linear positive correlation between the right lobe and subject age with R2= 0.768

Scatter plot (4-6) shows the positve correlation between left lobe and subject aged with R2= 0.676 so that the study shows that there is positve correlations between thyroid volume and aged

5-2 Conclusions:

Based on the result of this study thyroid measurement the study conclude that, Right lobe is large volume than left lobe. Thyroid volume increase with age increase, more affected age was 48 years old. And there is linear correlations between age and volume of right and left lobe.

5-3 Recommendations:

This study recommended that:

* Further study with large sample size.

* Other study o correlate between thyroid volume in male and female.

* Other study using advance ultrasound imaging e.g. elastography and Doppler to measure indices of blood supply thyroid gland.

* Other imaging modalities compare with ultrasound to measure thyroid volume in male and female

* Further study to compare between different State in Sudan.

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FACALTY OF GRAADULATE STDIES

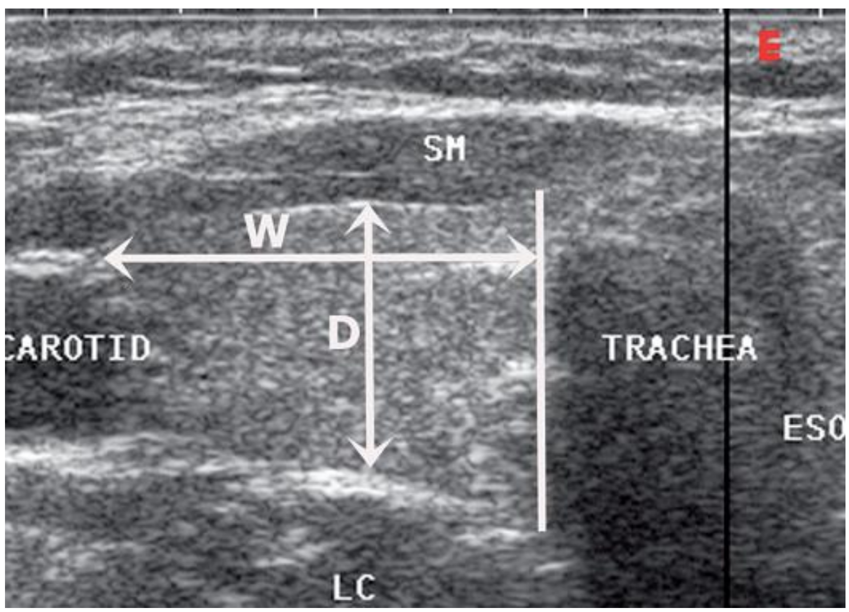
Data Collection Sheet of M.Sc Thesis in:

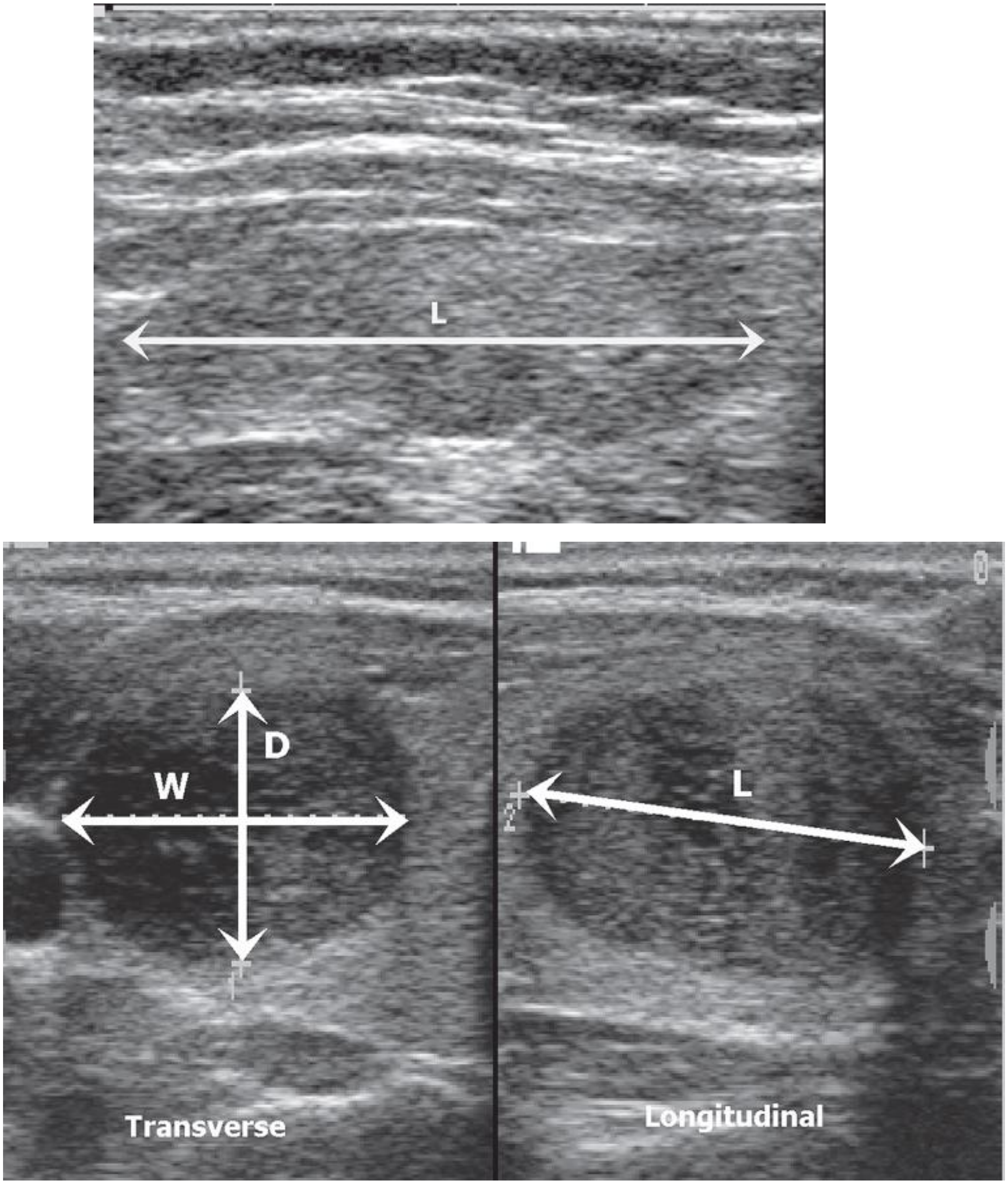
Measurement of Thyroid Gland Volume using Ultrasound Imaging

Patients data					Ultrasound Finding		
No	age	gender	weight	height	Volume	Texture	Echogensity
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

*Volume in Grams * Height in Centimeters


UTM SKUDAI
Thyroid
ISTHMUS
CAROTID
TRACHEA
RT
LT


E
SM
W
D
CAROTID
TRACHEA
ESO
LC



35 years old female measurement of normal her thyroid in different plane


SonoScape
FPS 35
D/G 100/5
GN 173
I/P 0/10
PWR 80
FRQ 9.5-15.0
D 4.3cm
L-Thyroid
THI


SonoScape
Dr. Birady Yousif
L742/Thyroid
MI 0.7
TIS 0.1
General
Collection
Distance
Area
Volume
Angle
Measurement
3Dist
EllipseDist
Exit
THI