Sudan University of Science and Technology

College of Graduate studies

Characterization of Parathyroid Gland Lesions Using Ultrasound and Scintigraphy

توصيف اورام الغدة الجار درقية باستخدام الموجات فوق الصوتية و التصويربالنظائر المشعة

A thesis submitted for partial fulfillment of M.Sc. degree in Diagnostic Medical Ultrasound

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بسم الله الرحمن الرحيم

ربي اشرح لي صدري واحلل العقدة من لساني يفقهو قولي

صدق الله العظيم

Dedication

To;

My parents…

My husband

And my daughters…

For my sons…

My brothers & sisters and all friends…

Acknowledgment

First of all, I thank Allah the Almighty for helping me complete this project. I thank Dr. Mohamed Elfadil Mohamed, my supervisor, for her help and guidance.

I would like to express my gratitude to college of medical radiological science members and staff, and the whole staff of the diagnostic radiology department, SKMC medical center for their great help and support.

I am greatly indebted to my husband, for bearing with me during the past several months.

Finally I would like to thank everybody especially my brothers in college of medical radiological science who helped me prepare and finish this study.

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Abstract

The main objective of this study was to characterize parathyroid gland using ultrasound and scintigraphy. The data of this study were collected from 50 patients referred to Abu Dhabi hospital; they were suffering from Adenoma, hyperparathyroidism, renal disease and Hypercalima. The results of this study using ultrasound and scintigraphy showed that; the most of the affected patients were female (86%) with an average age above 50 years and the common type of abnormality was adenoma (36%) and hyperparathyroidism (46%). The predominant sonographic features were hypoechoic appearance (82%) with Heterogeneous pattern. In summary ultrasound and nuclear medicine together they can give a complete description and characterization of parathyroid gland concerning the appearance, uptake, focal lesion status and the common site of the lesion; where hyperparathyroidism represents the common cases in male and female, while hypoechoic is the general appearance in case of adenoma and hyperparathyroidism. Heterogeneous texture is the characteristics of cases with adenoma and hyperparathyroidism.

المستخلص

كان الهدف الرئيسي من هذه الدراسة هو توصيف فرط الغدة الجار درقية باستخدام الموجات فوق الصوتية و الطب النووي. قد تم جمع بيانات هذه الدراسة من ٥٠ مرض محولين إلى مستشفى أبوظبي وكانوا يعانون من الورم الحميد، زيادة نشاط الغدة، وأمراض الكلى و فرط كالسيوم الدم . أظهرت نتائج هذه الدراسة باستخدام الموجات فوق الصوتية و الطب النووي أن معظم المرضى المصابين كانوا من الإناث (٨٦٪) و متوسط أعمارهم فوق ٥٠ سنة ونوع الشائع من الشذوذ هو الورم الحميد (٣٦٪) والغددى (٤٦٪). كانت ملامح الموجات فوق الصوتية السائدة ظهور ناقص الصدى (٨٢٪) مع إلنمط غير المتجانس. في ملخص الموجات فوق الصوتية والطب النووي معا يمكنهما أن تعطيا وصفا كاملا وتوصيف الغدة الجار درقية بشأن المظهر، واللامتصاص، وحالة الآفة البؤري وموقع مشترك للآفة. ونجد أن فرط الحالات بوجد في الذكور والإناث، في حين ناقص الصدى هو المظهر العام في حالة الورم الحميد فى فرط الغدة الجار درقية مع نسيج غير متجانس هي الخصائص.

List of abbreviations

NM	Nuclear medicine
SKMC	Sheik khalifa medical city
SPSS	Statistical Package for Social Sciences
US	Ultrasound

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Chapter one

Introduction

The parathyroid glands are four or more small glands, about the size of a grain of rice, located on the posterior surface of the thyroid gland. The parathyroid glands usually weigh between 25 mg and 40 mg in humans. There are typically four parathyroid glands. The two parathyroid glands on each side which are positioned higher are called the superior parathyroid glands, while the lower two are called the inferior parathyroid glands. Occasionally, some individuals may have six, eight, or even more parathyroid glands.

The parathyroid glands are named for their proximity to the thyroid but serve a completely different role than the thyroid gland. The parathyroid glands are quite easily recognizable from the thyroid as they have densely packed cells, in contrast with the follicle structure of the thyroid.[1][2] However, at surgery, they are harder to differentiate from the thyroid or fat.

Because the inferior thyroid arteries provide the primary blood supply to the posterior aspect of the thyroid gland where the parathyroid glands are located, branches of these arteries usually supply the parathyroid glands. However they may also be supplied by the branches of the superior thyroid arteries. Thyroid artery, laryngeal, tracheal or esophageal artery. Parathyroid veins drain into thyroid plexus of veins of the thyroid gland. Lymphatic vessels from the parathyroid glands drain into deep cervical lymph nodes and Para tracheal lymph nodes. In the histological sense, they distinguish themselves from the thyroid gland, as they contain two types of cells [3]

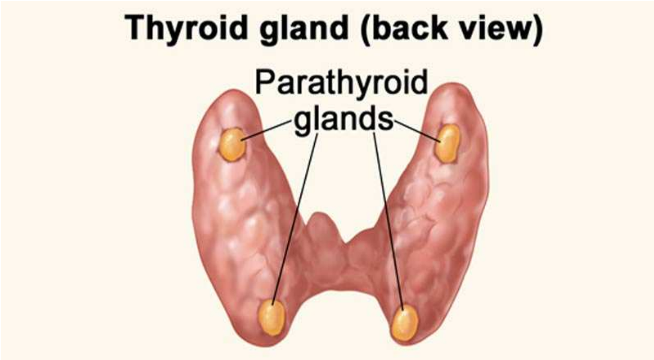

Figure (1.1) show the thyroid and parathyroid anatomy

Since hyperparathyroidism can only be treated with surgery, then it should be obvious to you that the goal of the operation is to remove ALL of the bad parathyroid glands. It should seem obvious as well, that if you have two bad parathyroid glands and your surgeon removes only one, and then you will not be cured. If we can get you to understand this simple fact, then we are half way there! Your parathyroid surgeon must remove all the bad parathyroid glands (and leave the normal ones behind!) or the surgery will be unsuccessful and the patient will not feel better or gain any benefit from the operation. Removing one tumor and leaving a second tumor behind (even a smaller one) does little or nothing for the patient. There is no benefit. US surgeons typically want to know what we are operating on before we operate. It makes us more confident before we put a knife on somebody's skin. Similarly, many of you will have an endocrinologist that wants to "see" the parathyroid tumor before he/she sends you to the surgeon. (Editor's note: this is the dumbest thing in the world--it is NOT the job of the endocrinologist to find the parathyroid tumor). Because US doctors like to "see" the tumor before we operate, we have been inventing different scans over the past 30 years in an attempt to "find the tumor". This page is all about that quest, and how dumb it really is--because it can't be done accurately. Sestamibi scans are the best scans to find a parathyroid tumor, BUT, they can find only about 50%. In other words, the tumor is present, but the scan does not have the resolution to find it. Therefore, at least 50% of parathyroid tumors cannot be seen with a sestamibi scan. Sestamibi scans are not as accurate as many doctors will have you believe. When a sestamibi scan is positive, it is wrong about half of the time. In other words, the "parathyroid tumor" they see on the scan is really a thyroid nodule, or the left lower parathyroid is actually the left upper. Don't get excited about your positive scan--it will be wrong half of the time. Most sestamibi scans are performed poorly by people who don't do them often, and these scans can't even find 35% of parathyroid tumors. Ultrasound can find about 60% of parathyroid adenomas (if the scan is actually performed by an endocrinologist or surgeon, or a tech that is experienced in parathyroid ultrasound and who has been told that that is what they are looking for!). However, ultrasound only finds the easy to locate, superficial tumors. The sound waves do not go deep enough and so they cannot find tumors deep in the neck, those up high in the neck, those in the chest, etc. A parathyroid tumor found on an ultrasound is a parathyroid tumor that any experienced parathyroid surgeon would find during a routine parathyroid operation, with a few rare exceptions. Ultrasound performed by a tech at your local x-ray place will find less than 25% of parathyroid tumors primarily because the physician that orders the scan almost always orders a "thyroid ultrasound". Thus the well-meaning, often very talented ultrasound tech doesn't know they are supposed to be looking for a parathyroid gland. We see this every single day and the scan was wasted.

If scans can't find half of the tumors that exist, then it is obvious that scans cannot be used to determine if a patient has hyperparathyroidism (scans cannot be used as diagnostic tools).If scans can't find half of the tumors that exist, then it is obvious that scans cannot be used to determine which patients should have an operation and which patients should be "observed" (scans cannot be used to make management decisions).Remember, most parathyroid tumors are only the size of an almond or grape and they are supposed to be deep in the neck behind the thyroid. The scans simply can't see the tumors because they are small and are hidden next to all of the other "stuff" in the neck! Also remember that these tumors make you sick because of the hormone they are producing, not because they are "big".

1.1. Physiology

The major function of the parathyroid glands is to maintain the body's calcium level within a very narrow range, so that the nervous and muscular systems can function properly. Parathyroid hormone (PTH, also known as parathormone) is a small protein that takes part in the control of calcium and phosphate homeostasis, as well as bone physiology. Parathyroid hormone has effects antagonistic to those of calcitonin. Calcium: PTH increases blood calcium levels by stimulating osteoclasts to break down bone and release calcium. PTH also increases gastrointestinal calcium absorption by activating vitamin D, and promotes calcium conservation (reabsorption) by the kidneys. Phosphate: PTH is the major regulator of serum phosphate concentrations via actions on the kidney. It is an inhibitor of proximal and also distal tubular reabsorption of phosphorus. Through activation of Vitamin D the absorption of Phosphate is increased. Too much calcium in the blood (hypocalcaemia) may not cause any symptoms at all or can cause a number of symptoms and medical conditions. These include: depression or mental confusion, kidney stones, bone and joint pain, abdominal pain and general aches and pains from no obvious cause. Through activation of Vitamin D the absorption of Phosphate is increased. Patients with parathyroid cancer have symptoms including: bone pain, kidney disease, and confusion, extremely high levels of parathyroid hormone in the blood, hoarseness and neck masses that can be felt with the hand

Sometimes the diagnosis of cancer is difficult to make, even after surgery. This is because parathyroid cancer cells look very similar to noncancerous adenoma cells. However, parathyroid cancer is so rare (less than 1% of all cases) that many head and neck surgeons (otolaryngologists) never see a patient with it.

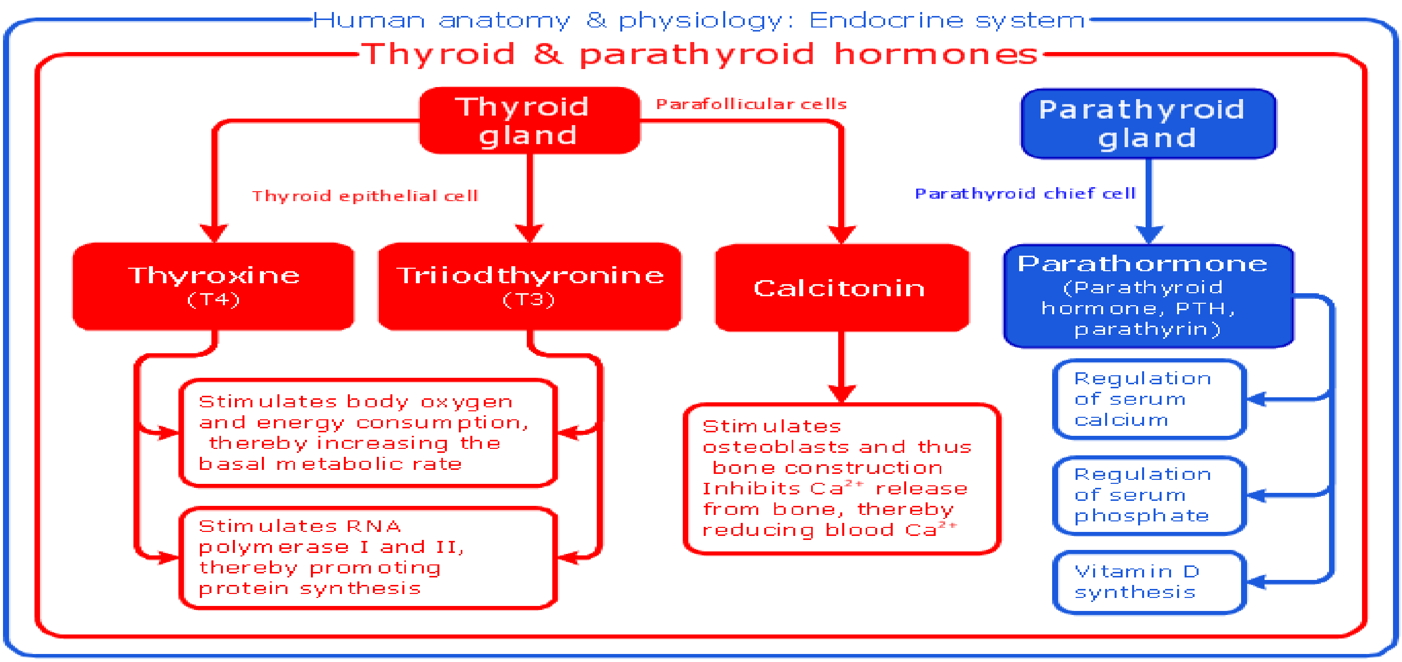

Figure (1.2) show the function and hormonal relation of the thyroid and parathyroid gland

1.2. Problem of the study:

Parathyroid gland is considered as one of the important part of the endocrine system gland which secrete significant level of hormones incorporated into the body nutrition metabolism such as calcium level in blood serum, so detection of parathyroid gland pathological condition related to its small size may lead to miss diagnosis due to its position with thyroid gland there for the use of ultrasound and nuclear medicine scan with best technique may lead to differentiate between the thyroid and parathyroid pathology also early detection of its morphological changes related to its site and size.

1.3. Study objective:

1.3.1. General objective:

The main aims of this study is to characterize the parathyroid gland pathology and morphology using ultrasound and scintigraphy in order to exclude the main pathological finding related to the nuclear medicine scan.

1.3.2. Specific objective:

- To characterize the parathyroid gland pathology using the ultrasound and nuclear medicine scan
- To measure the length and the width of the gland
- To correlate between the most pathological finding related to the age, shape of the gland
- To identify the echo-texture of parathyroid gland related to the finding and morphological shape.

1.4. Significance of the study

This study was highlighted on the investigation and characterization of parathyroid gland using ultrasound imaging correlated to the nuclear medicine functional imaging and this was provide a both functional and morphological characterization of the parathyroid gland disease and therefore accurate evaluation of its pathology and normal status. This research will provide recommendation on how to evaluate the important of the scintigraphy and ultrasound images in diagnosing parathyroid gland.

1.5. Overview of the study:

This study was consist of five chapters, chapter one was an introduction introduce briefly this thesis and contained (anatomy, physiology, pathology problem of study also contain general, specific objectives, significant of the study and overview of the study). Chapter two was literature review about role of US scan in diagnosis of parathyroid gland disease, and other modalities used. Chapter three was describe the methodology (material, method) used in this study. Chapter four was included result of presentation of final finding of study; chapter five included discussion, conclusion and recommendation for future scope in addition to references and appendices.

Chapter two

Literature review

2.1. Parathyroid gland pathology ultrasound

2.1.1. Shape

Parathyroid adenomas are typically oval or bean shaped as parathyroid glands enlarge, they dissect between longitudinally oriented tissue planes in the neck and acquire a characteristic oblong shape. If this process is exaggerated, they can become tubular or flattened.There is often asymmetry in the enlargement, and the cephalic and/or caudal end can be more bulbous, producing a triangular, tapering, tear dropor bilobed shape.(Charboneau JW et.al 1982, Randel SB et.al 1987).

2.1.2. Echogenecity and Internal Architecture

The echogenecity of most parathyroid adenomas is substantially less than that of normal thyroid tissue. The characteristic hypoechoic appearance of parathyroid adenomas is caused by the uniform hypercellularity of the gland with little fat content, which leaves few interfaces for reflecting sound. Occasionally, adenomas have a heterogeneous appearance, with are asof increased and decreased echogenecity. The rare, functioning parathyroid lip adenomas are more echogenecity than the adjacent thyroid gland because of their high fatcontent34 .A great majority of parathyroid adenomas are homogeneously solid. About 2% have internal cystic components resulting from cystic degeneration (most often) or true simple cysts (less often).35, 36 Adenomas may rarely contain internal calcification.

2.1.3. Vascularity

Color flow, spectral, and power Doppler sonography of an enlarged parathyroid gland may demonstrate a hypervascular pattern with prominent diastolic flow. An **enlarged extra-thyroidal artery**, often originating from branches of the inferior thyroidal artery, may be visualized supplying the adenoma with its insertion along the long-axis pole.37-42 A finding described in parathyroid adenomas is a **vascular arc,** which envelops 90 to 270 degrees of the mass. This vascular flow pattern may increase the sensitivity of initial detection of parathyroid adenomas and aid in confirming the diagnosis by allowing for differentiation from lymph nodes, which have a central hilar flow pattern. Asymmetric increased vascular flow may also be present in the thyroid gland adjacent to a parathyroid adenoma.

2.1.4. Size

Most parathyroid adenomas are 0.8 to 1.5 cm long and weigh 500 to 1000 mg. The smallest adenomas can be minimally enlarged glands that appear virtually normal during surgery but are found to be hypercellular on pathologic examination (Fig. 19-5; Video 19-1). Large adenomas can be 5 cm or more in length and weigh more than 10 g. Preoperative serum calcium levels are usually higher in patients with larger adenomas.31

2.1.5. Multiple Gland Disease

Multiple gland disease may be caused by diffuse hyperplasia or multiple adenomas. Individually, these enlarged glands may have the same sonographic and gross appearance as other parathyroid adenomas. However, the glands may be inconsistently and asymmetrically enlarged, and the diagnosis of multi-gland disease can be difficult to make sonographically. For example, if one gland is much larger than the others, the appearance may be misinterpreted as solitary adenomatous disease. Alternatively, if multiple glands are only minimally enlarged, the diagnosis may be missedal together.

2.1.6. Adenoma localization

2.1.6.1 Sonographic examination and typical locations

The sonographic examination of the neck for parathyroid adenoma localization is performed with the patient supine. The patient’s neck is hyper-extended by a pad centered under the scapulae, and the examiner usually sits at the patient’s head. High-frequency transducers (8-17 MHz) are used to provide optimal spatial resolution and visualization in most patients; the highest frequency possible should be used that still allows for tissue penetration to visualize the deeper structures, such as the long uscolli muscles. In obese patients with thick necks or with large multi-nodular thyroid glands, use of a5-MHz to 8-MHz transducer may be necessary to obtain adequate depth of penetration.

The pattern of the sonographic survey of the neck for adenoma localization can be considered in terms of the pattern of dissection and visualization that the surgeon uses in a thorough neck exploration. The typical superior parathyroid adenoma is usually adjacent to the posterior aspect of the mid-portion of the thyroid. The location of the typical inferior parathyroid adenoma is more variable but usually lies close to the lower pole of the thyroid. Most of these inferior adenomas are adjacent to the posterior aspect of the lower pole of the thyroid, and the rest are in the soft tissues 1 to 2 cm inferior to the thyroid. Therefore the examination is initiated on one side of the neck, centered in the region of the thyroid gland, with the electronic focus placed deep to the thyroid. High-resolution gray-scale images are obtained in the transverse (axial) and longitudinal (sagittal) planes. Any potential parathyroid adenomas detected in the transverse scan plane must be confirmed by longitudinal imaging to prevent mistaking other structures for an adenoma. Some authors recommend the use of compression of the superficial soft tissues to aid in adenoma detection.12, 41 This has been described as “graded” compression with the transducer to effect minimal deformity of the overlying subcutaneous tissues and strap muscles and increase the conspicuity of deeper, smaller adenomas (<1 cm). Color flow or power Doppler sonography is also used to assess the vascularity of any potential adenoma, aid in detection, and differentiation from other structures.38-42 Hyper-vascularity may be evident with a polar insertion of a prominent extra-thyroidal feeding artery, also with peripheral arcs of blood flow. After one side of the neck has been examined, a similar survey is conducted of the opposite side. However, 1%to 3% of parathyroid adenomas are frankly ectopic andnot found in typical locations adjacent to the thyroid. Therefore the sonographic examination must be extended laterally along the carotid sheaths, superiorly from the level of the mandible, and inferiorly to the level of the sternal notch and clavicles. The four most common ectopic locations are considered separately next.

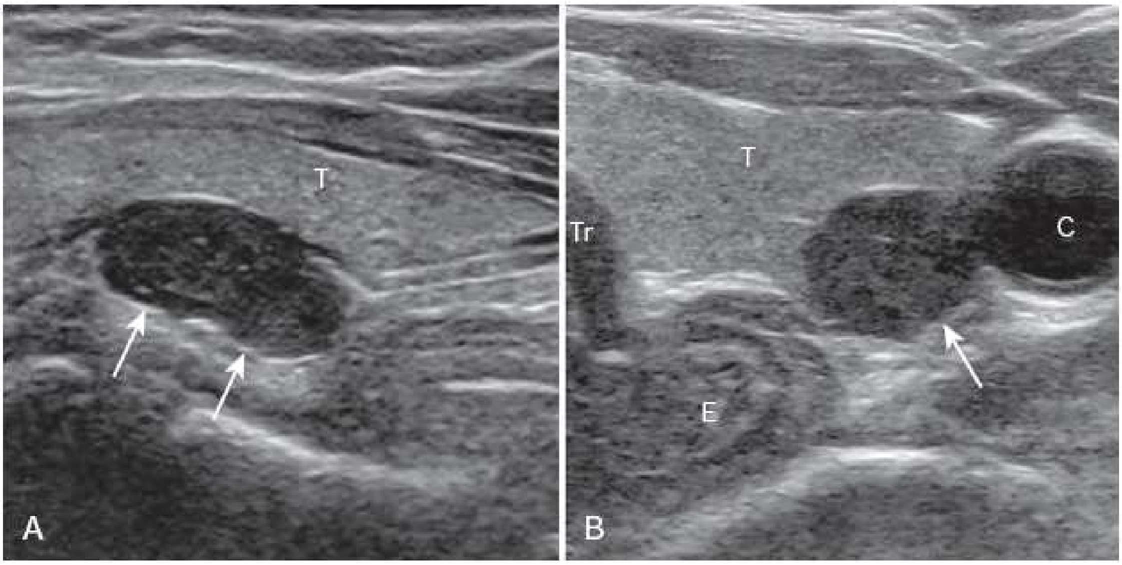

Figure 2.1. Superior parathyroid adenoma A, Longitudinal, and **B,** transverse, sonograms show an adenoma *(arrows)*adjacent to the posterior aspect of the midportion of the left lobe of the thyroid *(T); C*, common carotid artery; *E,* esophagus; *J,* internal jugular vein; *Tr,* trachea.

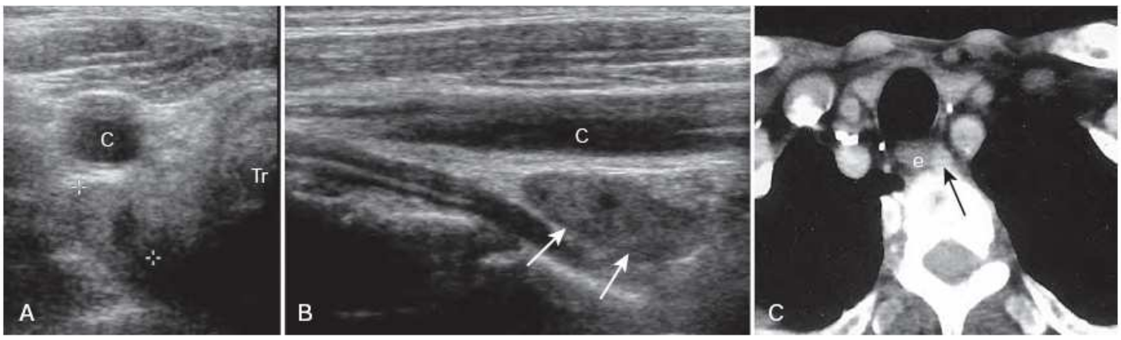

Figure 2.2. Ectopic superior parathyroid adenoma: tracheoesophageal groove. A, Transverse sonogram reveals an adenoma *(cursors)* arising from the right tracheoesophageal groove located posteriorly in the neck. The patient's head is turned to the left, which deviates the adenoma laterally and aids in visualization. *C,* Common carotid artery; *Tr,* trachea. **B,**

Corresponding longitudinal sonogram shows the ectopic superior parathyroid adenoma *(arrows)* posterior in the low neck adjacent to the cervical spine; *C,* common carotid artery. **C,** CT scan of the low neck/upper mediastinum in another patient shows an ectopic adenoma *(arrow)* in the left tracheoesophagealgroove adjacent to the esophagus *(e).*

2.1.6.2. Ectopic Locations Retrotracheal Retroesophageal Adenoma

Superior adenomas tend to enlarge between tissue planes that extend toward the posterior mediastinum; the most common location of an ectopic superior adenoma is deep in the neck, posterior or posterolateral to the trachea or esophagus (Fig. 19-10; Video 19-5). Acoustic shadowing from air in the trachea can make evaluation of thisarea difficult. The transducer should be angled medially to visualize the tissues posterior to the trachea. Often theadenoma protrudes slightly from behind the trachea, and only a portion of the mass will be visible. Turning the patient's head to the opposite side will accentuate the protrusion and provide better accessibility to the retrotracheal area. This process is then repeated on the other side of the neck to visualize the contralateral aspect of the retrotracheal area. This process is analogous to the maneuver that a surgeon uses to run a fingertip behind the trachea in an attempt to palpate a retrotracheal adenoma. Maximal turning of the head also often causesthe esophagus to move to the opposite side of the tracheaas it becomes compressed between the trachea and thecervical spine. If the examiner sees the esophagus movecompletely from one side of the trachea to the oppositeside during maximal head turning, the esophagus has effectively "swept" the retrotracheal space and will havepushed any parathyroid adenoma in this location outfrom behind the trachea.

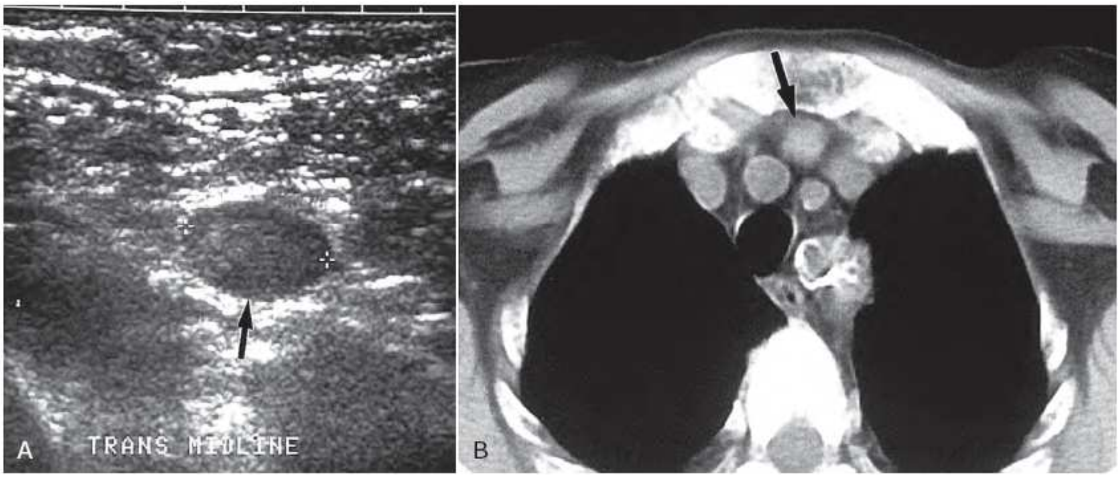

Figure 2.3. Ectopic parathyroid adenoma: anterosuperior mediastinum. A, Transverse sonogram angled caudal to the clavicles shows an oval, 1-cm ectopic inferior parathyroid adenoma *(arrow)* in the soft tissues of the anterosuperior mediastinum. **B,** CT scan of the upper mediastinum shows the ectopic adenoma *(arrow)* in the anterosuperior mediastinum, deep to the manubriumand adjacent to the great vessels.

2.1.7. Persistent or recurrent hyperparathyroidism

Persistent hyperparathyroidism is the persistence of hypercalcemia after previous failed parathyroid surgery.This is frequently caused by an undiscovered ectopicparathyroid adenoma or unrecognized multiple glanddisease, with failure to resect all the hyperfunctioning tissue during surgery.51-53 Recurrent hyperparathyroidism is defined as hypercalcemia occurring after a 6-month interval of normocalcemia, resulting from the new development of hyper functioning parathyroid tissue from previously normal glands.54 Recurrent hyperparathyroidism is often seen in patients with unrecognized MEN syndromes. Because of scarring and fibrosis from previous surgery,the curative rate for repeat surgery is lower than for initial surgery; the risk of recurrent laryngeal nerve damage and postoperative hypocalcaemia from hyperparathyroidism may also be greater.55,56Imaging before reoperation is particularly beneficial, and most care strategies recommend liberal use of imaging studies in this situation. 53,56-60 Ultrasound is an effective first-line imaging modality in the preoperative and reoperative assessment of parathyroid disease, providing anatomic localization with a relatively inexpensive, noninvasive method that avoids the use of ionizing radiation.41,42,59,60 During sonographic evaluation of reoperative patients, specific attention is paid to the most likely ectopic parathyroid locations—those associated with a gland that was not discovered at the initial neck dissection. A small subgroup of patients who develop recurrent hyperparathyroidism underwent previous auto-transplantation of parathyroid tissue in conjunction with previous total parathyroidectomy, typically for complications of chronic renal failure. Hyperparathyroidism in the setting of parathyroid auto-transplantation is referred to as graft-dependent hyperparathyroidism**.** In parathyroid auto-transplantation, a gland is sliced into fragments that are inserted into surgically prepared intramuscular pockets in the forearm or sternocleidomastoid muscle. Normal-functioning auto-transplanted parathyroid grafts are typically too small and similar in echotexture to the surrounding muscle to be adequately visualized sonographically. However, graft-dependent recurrent hyperparathyroidism can be imaged sonographically, appearing as oval, sharply marginated, hypo echoic hyper vascular nodules measuring 5 to 11 mm and similar in appearance to hyper functioning parathyroid glands or adenomas arising in the neck61. The hyperfunctioning auto-transplanted fragments usually can be found by the surgeon while the patient is under local anesthesia, and a portion of the grafted tissue can be excised to cure the hypercalcemia. Occasionally, for patients who are not candidates for repeat surgery, ultrasound-guided percutaneous ethanol injection may be used for ablation of recurrent hyperparathyroid disease in the neck or at a graft site.

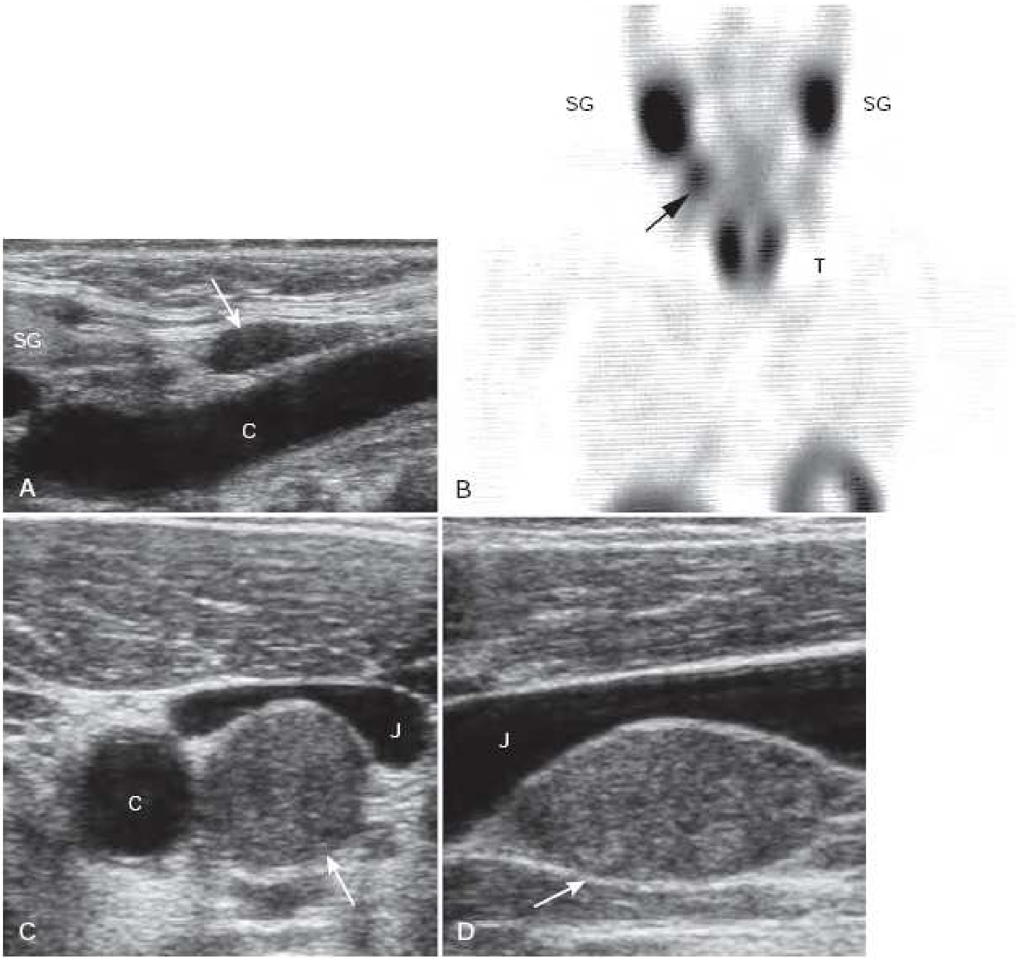

Figure 2.4. Ectopic parathyroid adenoma: near carotid sheath. A, Longitudinal sonogram of right side of the neck shows an ectopic undescended parathyroid adenoma *(arrow)* external to the carotid sheath, anterior to the common carotid artery *(C)*.Ultrasound-guided biopsy confirmed parathyroid tissue before surgical exploration. *SG*, Submandibular gland. **B,** Scintigraphy using technetium-99m sestamibi and coronal SPECT imaging shows a focal area of increased activity in right superior lateral neck

*(arrow),*which corresponds to the ectopic adenoma; *SG,* salivary glands; *T,* thyroid. **C,** Transverse, and **D,** longitudinal, sonograms in another patient show an ectopic left inferior adenoma *(arrow)* located within the carotid sheath, posterior to the internal jugular vein *(J).* Ultrasound- guided biopsy confirmed parathyroid tissue before surgical exploration. At surgery, the adenoma was adherent to the vagus nerve. *C,* Common carotid artery.

2.2. Previous study:

Solbiati et.al 2001 aimed to evaluate the Ultrasound of thyroid, parathyroid glands and neck lymph nodes In the past 15 years high-frequency B-mode sonography and colour–power Doppler have become the most important and most widely employed imaging modalities for the study of the neck, in particular for thyroid gland, parathyroids and lymph nodes. Sonography allows not only the detection but often also the characterization of the diseases of these organs, distinguishing benign from malignant lesions with high sensitivity and specificity, which could be further improved by the employ of ultrasound contrast agents and harmonic imaging. Although no single sonographic criterion is specific for benign or malignant nature of the lesions, the combination of different signs can be markedly helpful to speed up the diagnostic process. Fine-needle aspiration biopsy (FNAB) remains the most accurate modality for the definitive assessment of thyroid gland nodules and of any doubtful case of nodal disease. In association with clinical findings and serum levels of parathormone, FNAB has specificity close to 100% for the characterization of parathyroid adenomas. A combined approach with sonography and FNAB is generally highly effective

Kamaya et.al 2006 aims to evaluate the parathyroid gland abnormality in 80% to 90% of patients with primary hyperparathyroidism, a single parathyroid adenoma will be identified as the culprit, whereas the remaining 10% to 20% are caused by multiple adenomas, parathyroid hyperplasia, and rarely, parathyroid carcinoma. At the 2002 National Institute of Health consensus meeting, minimally invasive parathyroidectomy was endorsed as a promising and attractive alternative to total parathyroidectomy. Therefore, preoperative localization of the adenoma is critical in the clinical evaluation of the patient before surgical resection. Although adenomas less than 1 cm may be difficult to visualize sonographically, knowledge of typical imaging characteristics of parathyroid adenomas and use of special sonographic techniques will facilitate identification in most patients. Typical imaging characteristics of parathyroid adenomas include homogeneously hypoechoic echotexture on gray scale with an enlarged feeding artery and peripheral arc of vascularity seen on color and power Doppler. Proper neck extension, unilateral graded compression techniques, and patient swallowing will improve visualization of adenomas.

Gretchen Pet.al 1999 studied theParathyroid Localization with High-Resolution Ultrasound and Technetium Tc 99m Sestamibi**.** Ultrasound and sestamibi scanning were performed in patients undergoing neck exploration for hyperparathyroidism. If the 2 scans agreed in identifying a single adenoma, and surgery confirmed the location of a single adenoma and an ipsilateral normal gland, a unilateral exploration was performed. His study was carried on University tertiary care center on Sixty-one consecutive patients undergoing surgery for hyperparathyroidism from September 1, 1994, through September 30, 1997. High-resolution ultrasound was performed in 59 patients and sestamibi scanning in 58 patients; all patients underwent neck exploration by a single surgeon; results of preoperative ultrasound and sestamibi scanning were compared with operative and histological findings which showed that all patients were cured of hypercalcemia. Specificity of ultrasound and sestamibi scanning was 98% and 99%, respectively; however, their sensitivity was only 57% and 54%, respectively. Both imaging modalities had lower sensitivities in the setting of multigland disease. If both imaging studies were considered as a single test, sensitivity for imaging in patients with primary hyperparathyroidism reached 78%. Our localization protocol allowed a unilateral approach in 43% of patients (23 of 53). These results confirm the value of preoperative localization in patients with hyperparathyroidism. A unilateral approach can be used with a high degree of success in cases when ultrasound and sestamibi scanning agree in the identification of a single adenoma confirmed by surgical exploration with the identification of a normal ipsilateral gland.

C.N. Patel et.al 2010 amied to evaluate the accuracy of ultrasound and parathyroid scintigraphy using single photon-emission computed tomography/computed tomography (SPECT/CT) for the preoperative localization of solitary parathyroid adenomas in patients with primary hyperparathyroidism who would be suitable for minimally invasive parathyroid surgery. Retrospective study of 63 consecutive patients with biochemical evidence of primary hyperparathyroidism referred for preoperative localization of parathyroid adenoma that proceeded to surgery in the same institution. All patients underwent high-resolution ultrasound and Technetium-99m sestamibi scintigraphy with planar and SPECT/CT imaging. The accuracy of preoperative imaging was compared to surgical and histological findings as the reference standard. Fifty-nine patients had solitary parathyroid adenomas, three patients had multiglandular hyperplasia, and one patient had multiple parathyroid adenomas confirmed at surgery and histology. Thirty-five solitary parathyroid adenomas were identified preoperatively with ultrasound (64%) and 53 with SPECT-CT (90%). Concordant ultrasound and SPECT/CT findings were found in 35 cases (59%). An additional three adenomas were found with ultrasound alone and 18 adenomas with SPECT/CT alone. Fifty-one of the 56 adenomas localized using combined ultrasound and SPECT/CT were found at the expected sites during surgery. Combined ultrasound and SPECT/CT has an overall sensitivity of 95% and accuracy of 91% for the preoperative localization of solitary parathyroid adenomas. The combination of ultrasound and SPECT/CT has incremental value in accurately localizing solitary parathyroid adenomas over either technique alone, and allows selection of patients with primary hyperparathyroidism who would be suitable for minimally invasive surgery.

M. Kebapci et.al 2004 was aimed to evaluate the sensitivity and usefulness of high resolution ultrasonography (US) and dual phase technetium-99m sestamibi (Tc-MIBI) scintigraphy in the preoperative localization of parathyroid lesions in patients with or without thyroid disease and to define the impact of the presence of thyroid disease on these methods. Preoperative US and scintigraphy were performed on 52 patients with primary hyperparathyroidism. Age, gender, preoperative parathyroid hormone level, serum calcium level, serum phosphate level, diameter, location, associated with thyroid abnormality, and results of parathyroid exploration were determined in all patients. The results of US and Tc-MIBI imaging were analyzed and compared with surgical and histopathologic findings. At surgery, 56 parathyroid lesions were found in 52 patients (9 men, 43 women), the parathyroid lesion was solitary (47 adenomas, two hyperplasias), in 2 patients double adenomas were present, in 1 patient three glands was affected by hyperplasia. Twenty-seven patients had concomitant thyroid disease. The overall sensitivity of US and Tc-MIBI scintigraphy was 84% and 73%, respectively. In patients without thyroid disease, the sensitivity of these techniques was 90% and 75%, respectively. In patients with thyroid disease, the sensitivity was 78% and 70%, respectively. In patients with thyroid disease, the combined sensitivity of these techniques was 89%. These results allow the conclusion that, inexperienced hands, US is a highly sensitive technique. Especially in patients with no thyroid pathology and typical located gland, US alone should be used as a first step for preoperative localization of parathyroid lesions. When negative, Tc-MIBI scintigraphy is suggested. In patients with concomitant thyroid disease, the combination of US and Tc-MIBI scintigraphy represents a reliable localization technique.

Chapter three

Methodology

3.1. Material:

Bright view XCT (Philips) gamma camera, Low energy, high resolution collimator and low energy general purpose collimator, Pin-hole collimation should never be used, Window: 20%, Magnification: 1.6 on computer only (high mag images should NEVER be used).Computer: PHILIPS, and the radiopharmaceutical used was Tc-99m sestamibi (mibi) injected intravenously, dose: 20mCi (740Mbq) (+/- depending on extremes of body weight)

3.2. Method:

Fifty patients underwent preoperative high-resolution sonography. Both longitudinal and transverse images of the neck were obtained from the level of the angle of the mandible to the sternal notch by means of 7- to 10-MHz transducers. Parathyroid gland was identified on gray-scale imaging by the characteristic appearance of the thyroid gland. Three patients had scans all other patients had scans performed at the Department of Radiology, SKMC, abudhabi, also these patient underwent nuclear medicine scan for further assessment and clinical correlations so lemon juice within 20 minutes of initial imaging is given to the patient to prevent the salivary gland uptake, (20% juice, 80% water). The patient was positioned in front of the camera in supine position in order to scan the neck area. Ten minutes to 1 hour (10 to 20 minutes if being performed immediately prior to minimal parathyroid surgery (the MIRP procedure) using intraoperative nuclear mapping) (About 98% of our scans are completed in 20 minutes or less).

3.2.1. Duration of the study

This study was conducted from January 2013- august 2015

3.2.2. Study design:

This is a descriptive study of a cross-sectional type where the data were collected retrospectively.

3.2.3. Sampling of the study:

The sample of this study consisted of 50 patients underwent Tc^{99m}-sestamibi scan and ultrasonography.

3.2.4. Area of the study

All the patients are referred to our department from different clinics in our hospital in Abu Dhabi

3.2.5. Inclusion criteria

All adult patients from both sexes suffering from lesion in the parathyroid gland referred for examination by scintigraphy and ultrasound scan

3.2.6. Exclusion criteria

Patient with surgical removal of thyroid and parathyroid gland was excluded from this study

3.2.7. Method of Data collection

We will study 50 consecutive patients parathyroid disease diagnosed at our institution between Januarys 2013 and august 2015.

3.2.8. Method of data analysis:

All data were presented as mean±SD values. Data were analyzed by an independent t test and by correlation analysis with the use of the SPSS(Inc., Chicago, Illinois version 16). A value of $P<0.05$ was considered significant.

3.2.9. Method of data collection:

The data were collect on master data sheet from the diagnostic stations which was including all parameters need for evaluations.

3.2.10. Variables of the study:

Patient gender, Age, History of disease and Sign and symptoms, disease type, echo-texture, length, width, and site of the parathyroid gland

3.2.11. Ethical issues:

- There was official written permission to Khartoum state diagnostic centers to take the data.
- No patient data were published also the data was kept in personal computer with personal password.

Chapter four
Results

Table 4-1 show the Mean ±SD of the variables used in the study

Items	Mean ±SD
Age	58.3±13.4
Width	03.8±3.9
Length	03.1±3.0
Size	21.1±31,7

Table 4.2 Show the frequency of gender

Gender	Frequency
Male	7
Female	43
Total	50

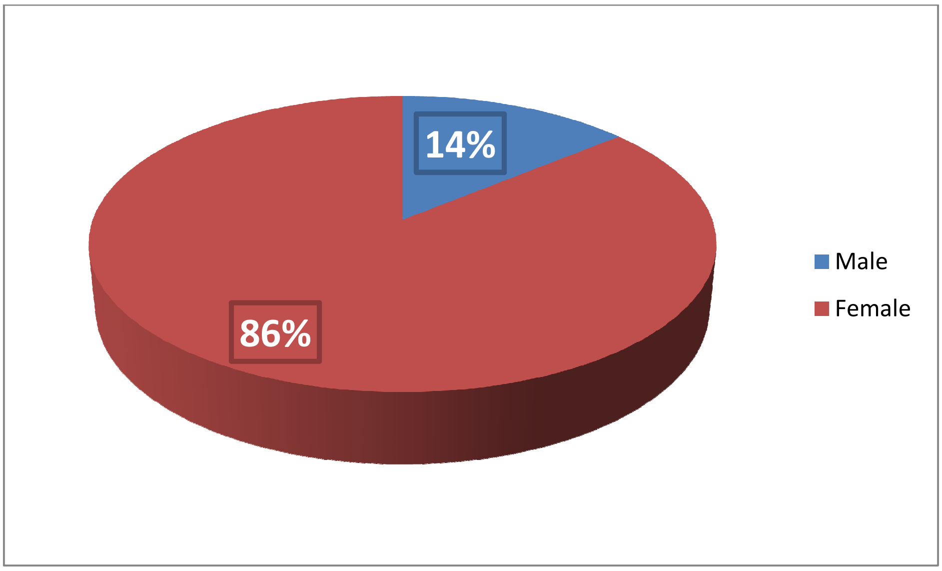

Figure 4.1 pie graph showed the frequency distribution of female to male percentage

Table 4.3 Show the frequency of diagnosis

Diagnosis	**Frequency**
Adenoma	18
Hyperparathyroidism	23
Renal disease	2
Hypercalima	7
Total	50

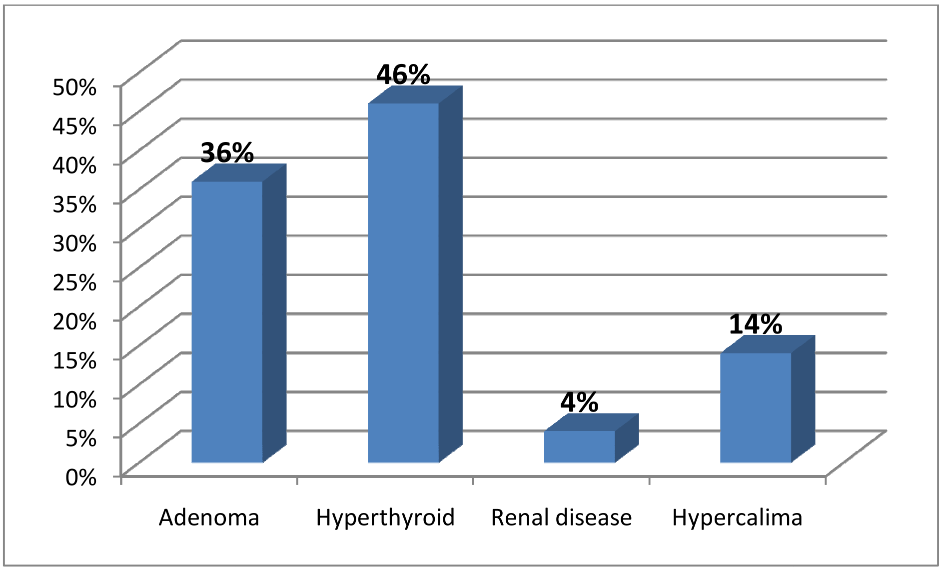

Figure 4.2 show the frequency distribution of the parathyroid common pathological condition

Table 4.4 Show the frequency distribution of the echo-texture that describe the parathyroid lesion

Echogenicity	Frequency
hypoechoic	41
Normal	9
Total	50

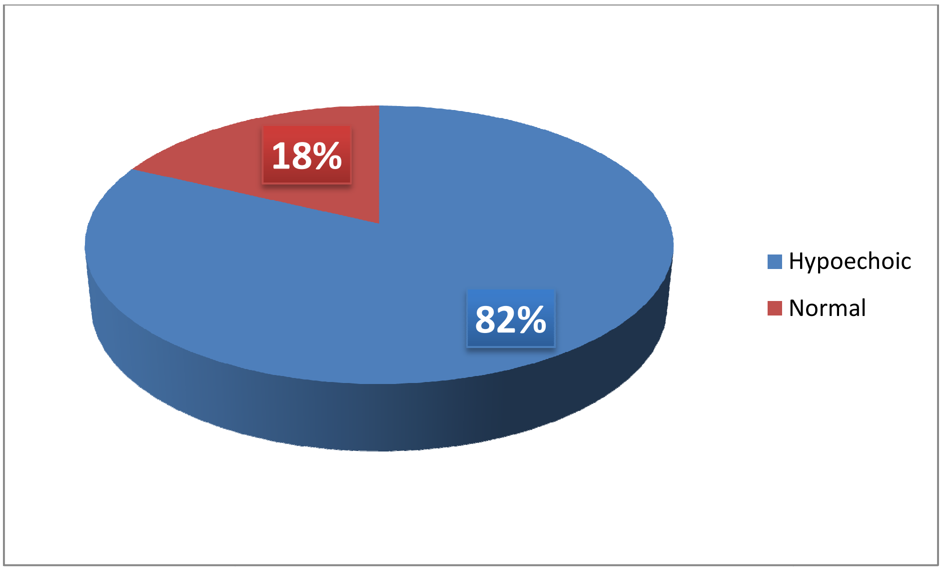

Figure (4.3) pie graph shows the percentage of the echogenecity for normal and hypoechoic lesion

Table 4.5 Show the texture distribution of parathyroid lesion

Texture	Frequency
Heterogeneous	42
Homogenous	1
Normal	7
Total	50

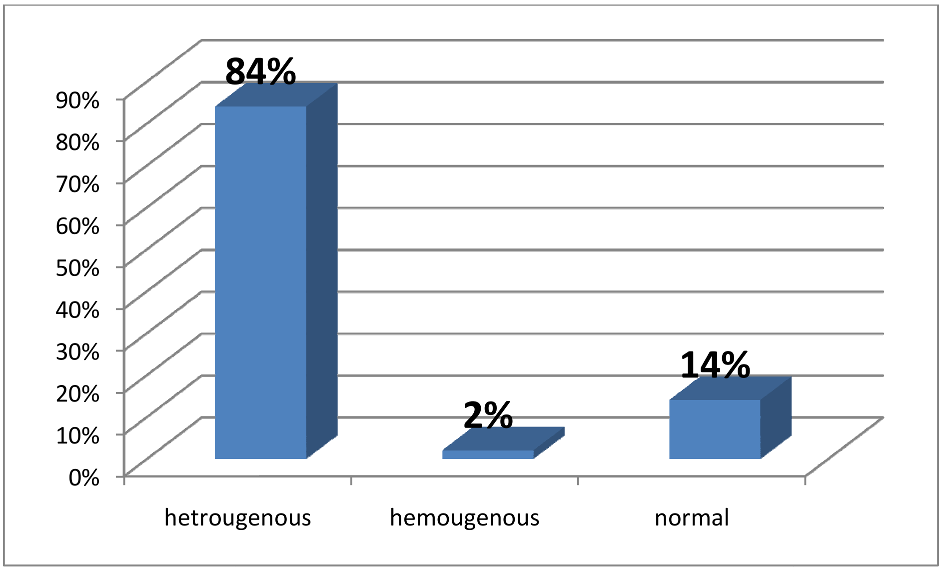

Figure 4.4 par graph show the percentage of texture distribution of lesion

Table (4.6) Show the frequency distribution of the appearance of the lesion

Appearance	**Frequency**
Well define	18
Ill define	15
Normal	17
Total	50

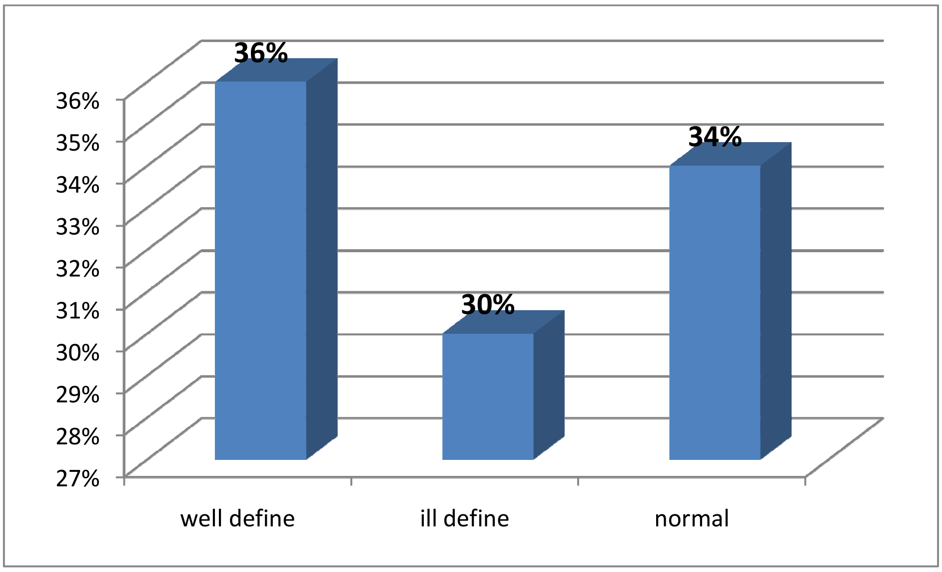

Figure 4.5 par graph show the distribution of the lesion appearance

Table 4.7 Show the frequency distribution of the focal and non-focal lesion

Lesion	**Frequency**
Focal lesion	38
No lesion	12
Total	50

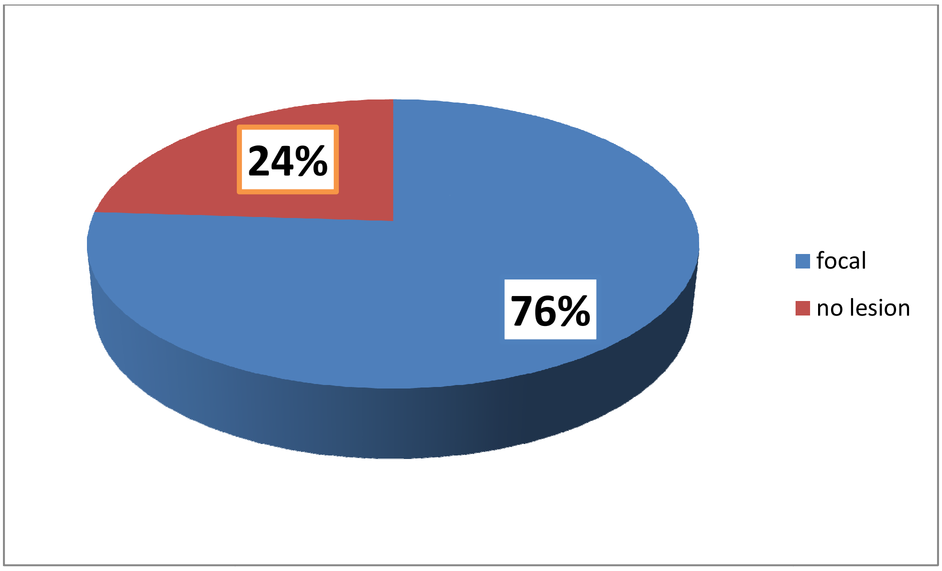

Figure (4.6) pie chart show the percentage of focal lesion to normal one

Table (4.8) show the frequency distribution of the lesion site through the thyroid lobes

Site	Frequency
Lt lobe	16
Rt lobe	23
Both lobes	3
Normal	8
Total	50

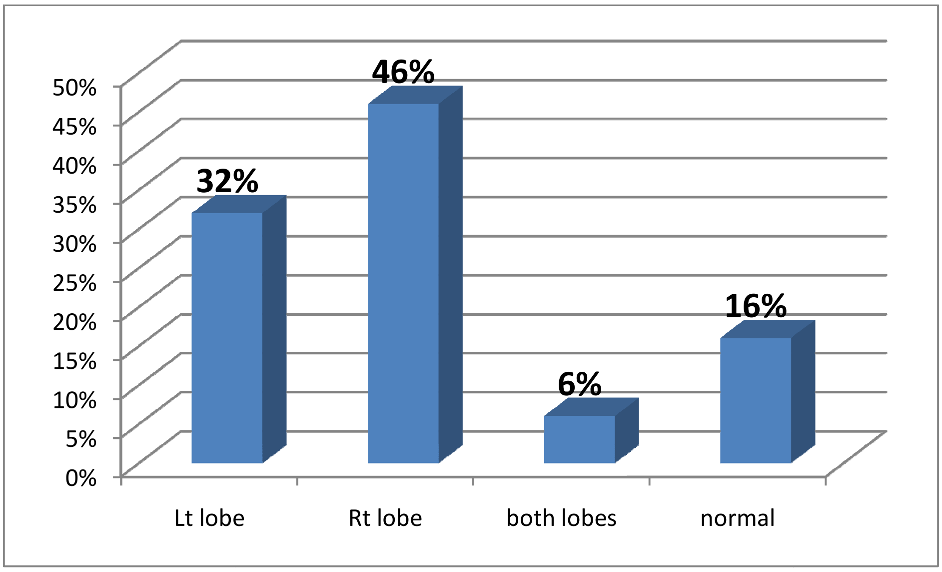

Figure 4.7 Show the percentage of parathyroid disease to the site of thyroid

Table 4.9 Show the frequency of the final result of the study

Result	Frequency
+ev	42
-ev	8
Total	50

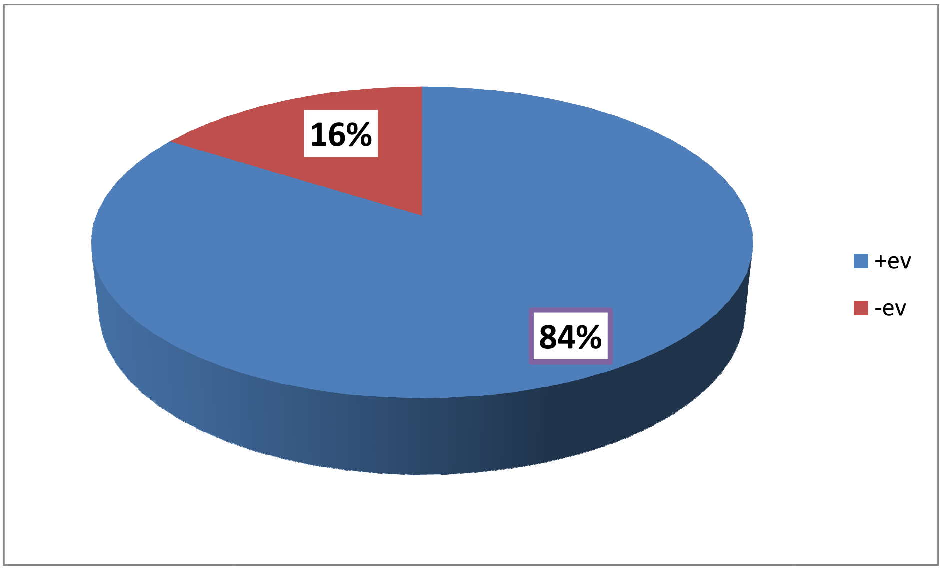

Figure (4.8) Show the percentage of positive result to the negative one

Table (4.10) show the frequency distribution of the parathyroid gland uptake NM scan

Uptake	**Frequency**
Increase	35
Decrease	4
No uptake	11
Total	50

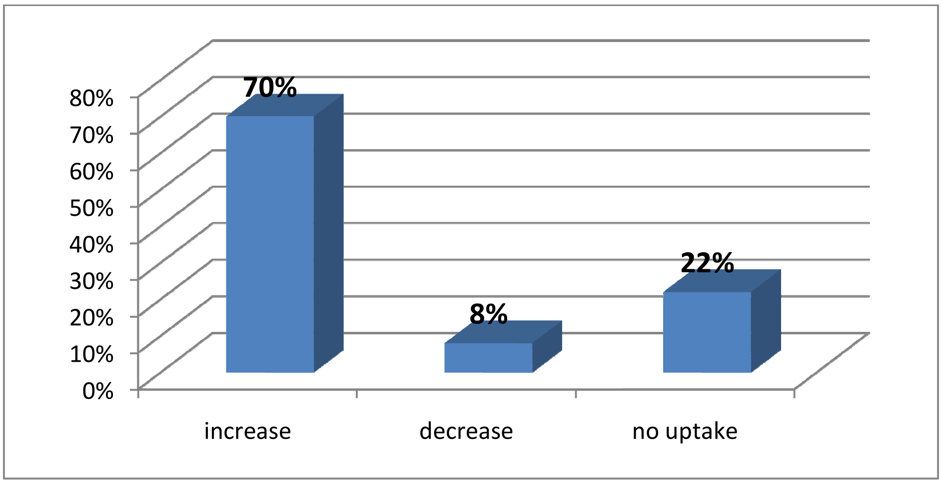

Figure (4.9) par graph show the percentage parathyroid gland uptake

Table (4.11) Show the us result compared with the nuclear medicine result

Ultrasound result	Positive result NM	Negative result NM	Total
Adenoma	14	4	18
hyperparathyroidism	21	2	23
Renal disease	2	0	2
Hypercalima	5	2	7
Total	42	8	50

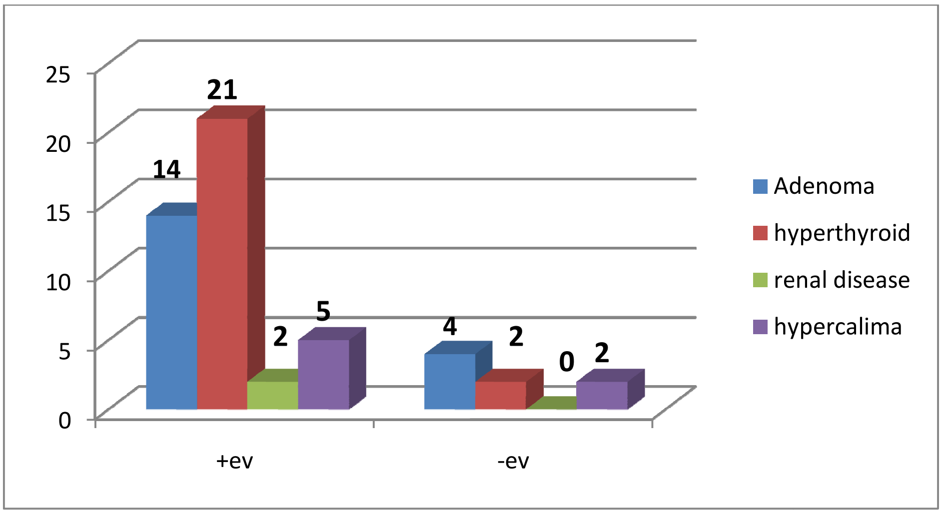

Figure (4.10) show the distribution of the positive and negative result of the study

Table (4.12) show combination of parathyroid lesion using US& NM studies

Ultrasound	Lesion NM		Total
	Focal lesion	No lesion	
Adenoma	16	2	18
Hyperparathyroidism	16	7	23
Renal disease	2	0	2
Hypercalima	4	3	7
Total	38	12	50

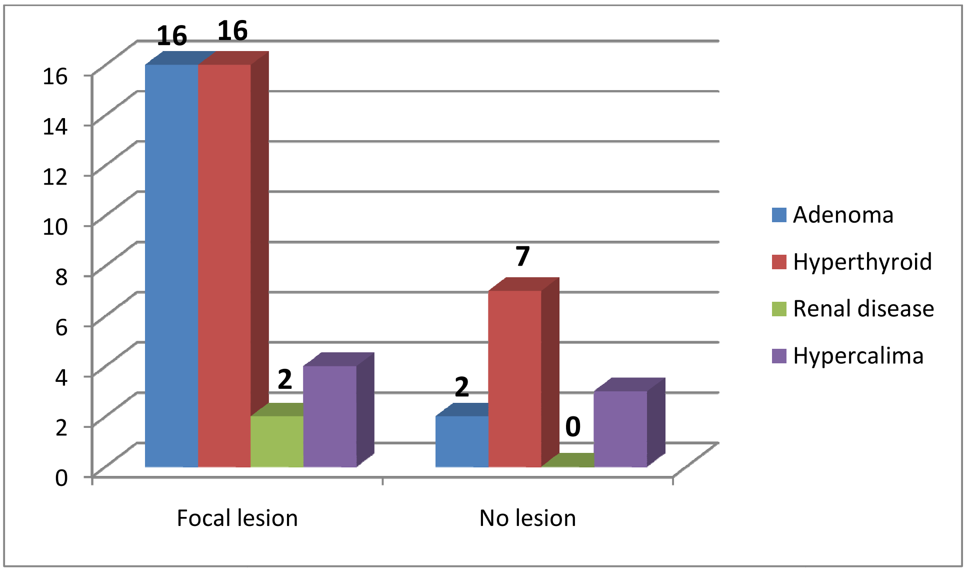

Figure (4.11) Show the appearance of the lesion compared to the diagnosis

Table (4.13) Show the site of the lesion in US & NM

Ultrasound	site NM				Total
	Lt lobe	Rt lobe	Normal	both lobes	
Adenoma	10	7	0	1	18
hyperparathyroidism	5	12	5	1	23
Renal disease	0	2	0	0	2
Hypercalima	1	2	3	1	7
Total	16	23	8	3	50

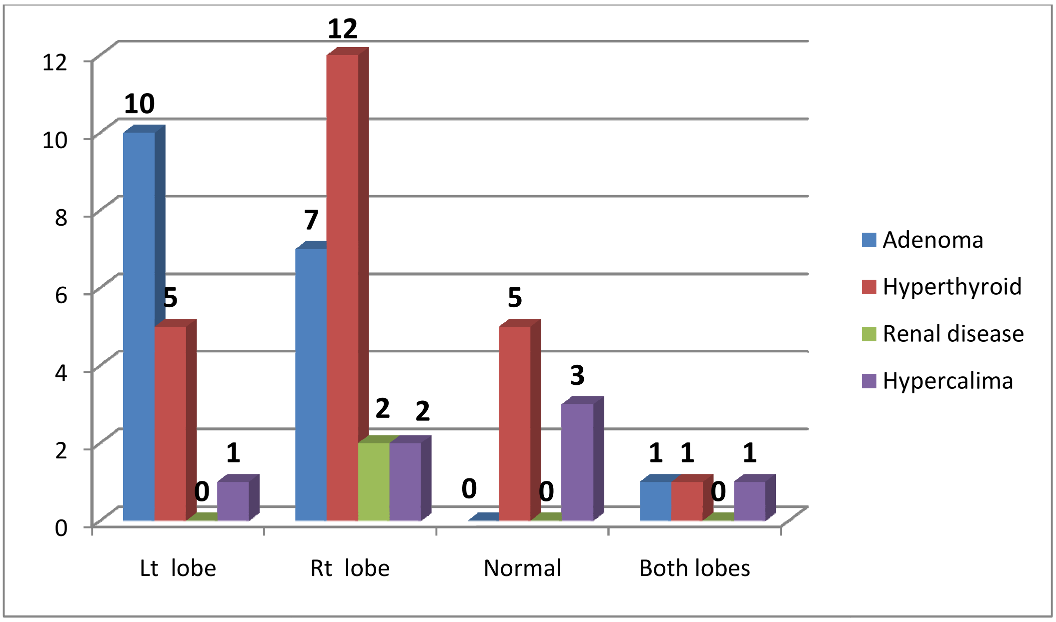

Figure 4-12 Show frequency distribution of the site of the lesion

Table 4-14 Show the frequency of the uptake of the lesion in NM

Ultrasound	uptake NM			Total
	Increase	Decrease	No uptake	
Adenoma	14	1	3	18
hyperparathyroidism	16	3	4	23
Renal disease	2	0	0	2
Hypercalima	3	0	4	7
Total	35	4	11	50

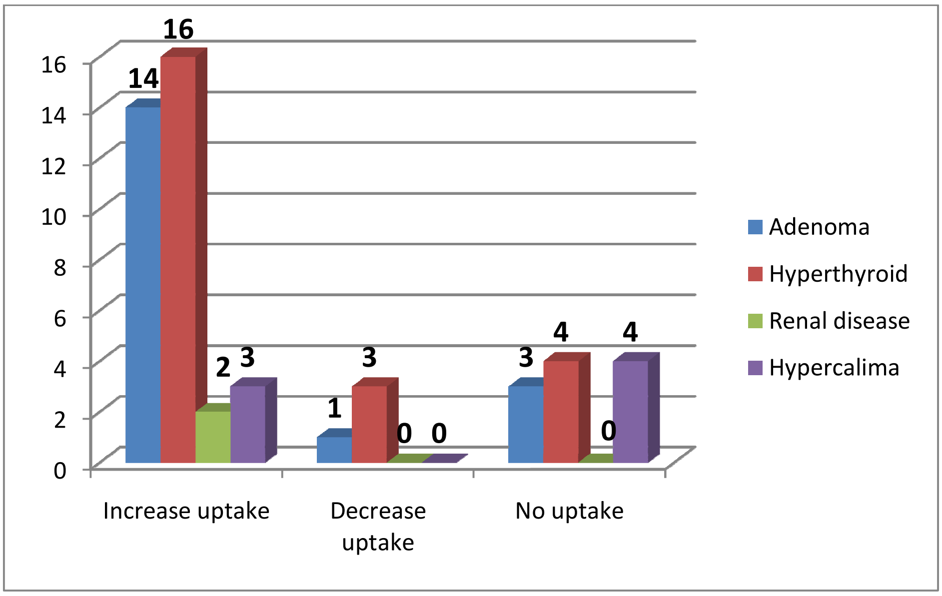

Figure (4.13) Show the frequency distribution of the result of the uptake

Table 4-15 Show the frequency distribution of the US appearance

Ultrasound	Appearance			Total
	well define	ill define	Normal	
Adenoma	7	5	6	18
hyperparathyroidism	6	9	8	23
Renal disease	1	0	1	2
Hypercalima	4	1	2	7
Total	18	15	17	50

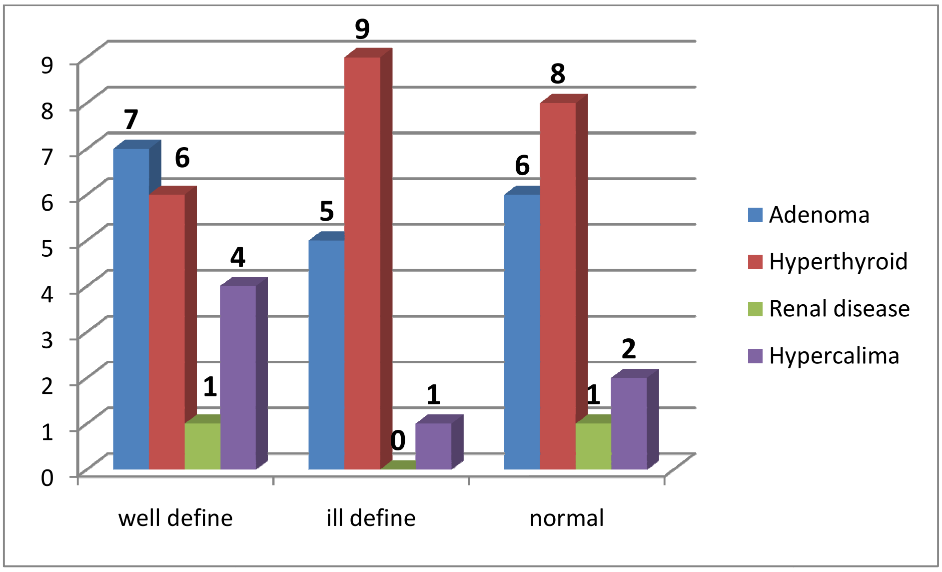

Figure 4-14 Show the parathyroid pathological shape appearance during NM scan

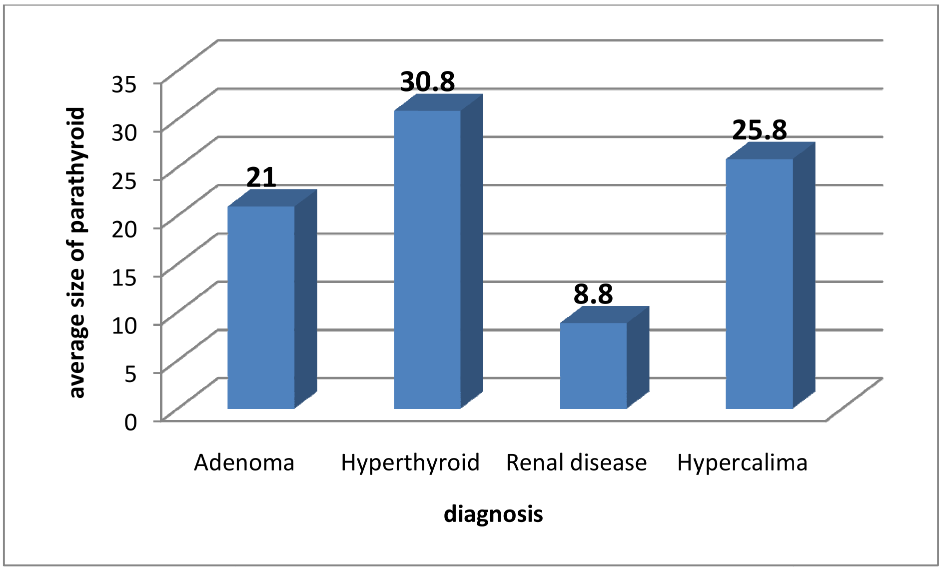

Figure 4-15 Show the average size of the parathyroid compared to the diagnosis

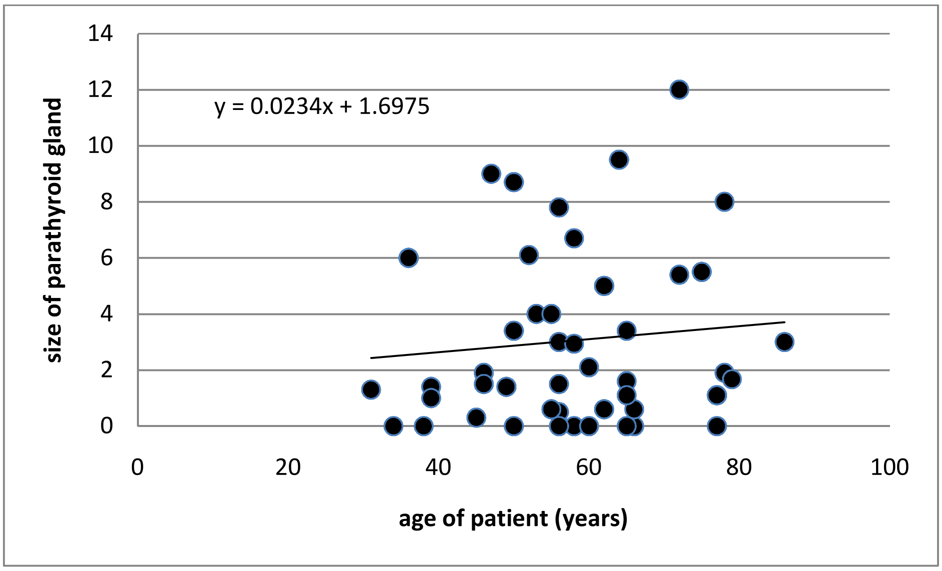

Figure 4-16 scatter plot show age of the linear relationship between the age and the size of parathyroid gland

Table 4-16 Show the relationship between the US disease and gender

Ultrasound	gender		Total
	Male	Female	
Adenoma	2	16	18
hyperparathyroidism	5	18	23
Renal disease	0	2	2
Hypercalima	0	7	7
Total	7	43	50

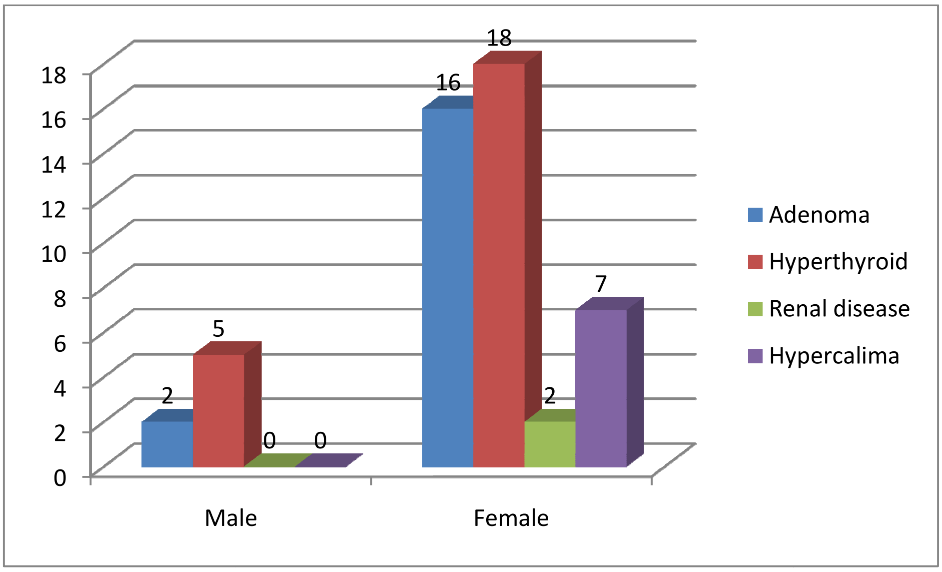

Figure 4.17 Bar graph show distribution of the disease among the male and female variable

Table 4-17 Show the frequency distribution of the echogenecity of the lesion

Ultrasound	Echogenicity		Total
	hypoechoic	Normal	
Adenoma	12	6	18
hyperparathyroidism	21	2	23
Renal disease	2	0	2
Hypercalima	6	1	7
Total	41	9	50

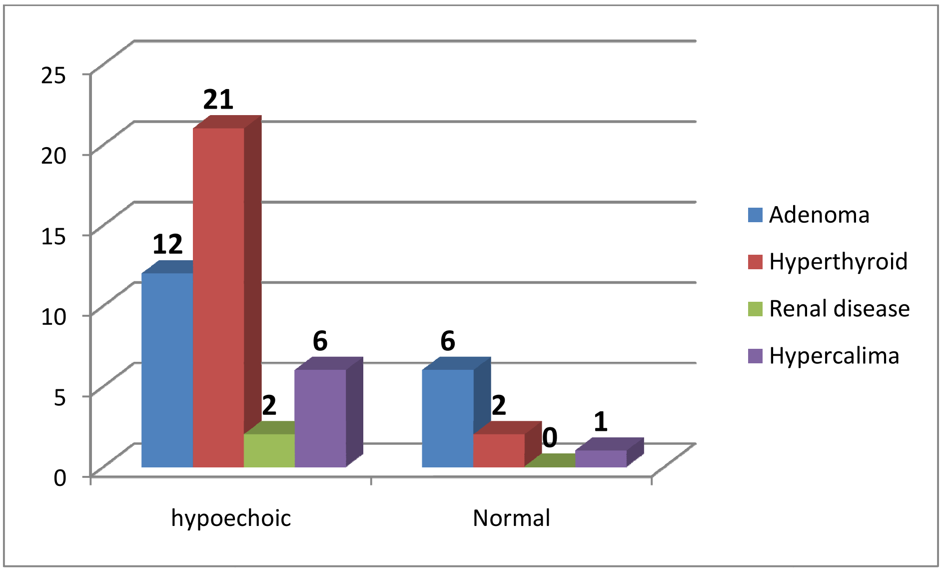

Figure 4-18 Bar graph show frequency distribution the echogenecity

Table 4-18 Show the frequency distribution of US texture of the lesion

Ultrasound	texture US			Total
	Heterogeneous	Homogenous	Normal	
Adenoma	14	0	4	18
hyperparathyroidism	20	1	2	23
Renal disease	2	0	0	2
Hypercalima	6	0	1	7
Total	42	1	7	50

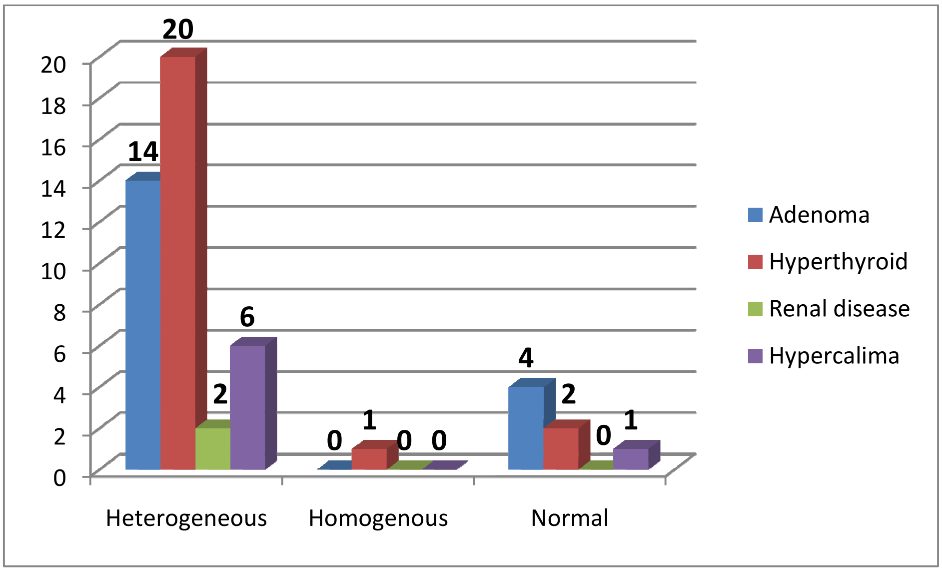

Figure 4.19 Bar graph show the texture of the parathyroid disease

Chapter five

Discussion, Conclusion and Recommendation

The data of this study was collected from patient having parathyroid problem using nuclear medicine imaging and ultrasound to characterize the findings using the two methods for better diagnosis outcome.

5-1 Discussion

The data of this study consisted of 50 patients their mean age was 58.3±13.4 (Table 5-1) years 86% were females (Figure 5-2) which means the predominant gender was female and mostly with older age. Diagnosis of these patient showed that there is 4 types of abnormality of the patient which include: adenoma, hyperparathyroidism, renal disease and Hypercalima; with a frequencies distributions of 18, 23, 2 and 7 patients respectively. This reflects that hyperparathyroidism condition represents the largest percentage 46% followed by adenoma which is 36% (Table 4-3 and Figure 4-2). Ultrasound results also showed that the appearance of parathyroid with the associated abnormality showed that 82% of the patient having hypoechoic echogenecity (41 patients) the rest was normal (Table 4-4 and Figure 4-3). Texture of the parathyroid gland showed that 84% of the patient showed Heterogeneous texture (42 patients). The result concerning echogenicity and texture reveals abnormal appearance of the parathyroid gland regard less the type of abnormality where the predominant appearance was hypoechoic with Heterogeneous pattern (Table 4-5 and Figure 4-4).

Nuclear medicine investigation concerning the appearance of parathyroid showed that 36% were well define, 30% ill define and 34% were normal in appearance (Table 4-6 and Figure 4-5) which means 66% showed abnormal appearance versus 34% look normal. 74% of the patients showed focal lesion (Table 4-7 and Figure 4-6). 46% of the abnormality occurs in the Rt lobe while 32% in Lt lobe (Table 4-8 and Figure 4-7). 80% of the cases showed positive result in nuclear medicine versus 16% showed negative results (Table 4-9 and Figure 4-8). While 70% of the cases showed an increased uptake and 22% with a no uptake and the rest with decreased uptake (Table 4-10 and Figure 4-9).

Adenoma, hyperparathyroidism, renal disease and hypercalima all showed a positive result in nuclear medicine; where adenoma showed those 4 negative cases out of 18 and 2 cases out of 23 of hyperparathyroidism (Table 4-11 and Figure 4-10). As well Adenoma showed out of 18 cases only 2 cases in nuclear medicine examination showed no lesion and for hyperparathyroidism out of 23 patient 7 of them showed no lesion; this means that adenoma and hyperparathyroidism mostly showed focal lesion in nuclear medicine examination results (Table 4-12 and Figure 4-11). Adenoma concerning the site of abnormality mostly occurs in the Lt Site 10 cases out 18, while hyperparathyroidism mostly associated with the Rt side 12 out of 23 cases (Table 4-13 and Figure 4-13).

hyperparathyroidism cases showed a largest mean size of parathyroid gland which is $38.8mm^2$ followed by Hypercalcemia which is $25.8mm^2$ then adenoma which is $21mm^2$. This means that these three types mostly present with enlargement of parathyroid gland. As well as the age of the patient increase the size of the parathyroid gland increases linearly by a factor of $0.02mm^2$/year (Figure 4-15 and 4-16). For male and female hyperparathyroidism represents the common cases as shown in Table 4-16 and Figure 4-17, while hypoechoic is the general appearance in case of adenoma and hyperparathyroidism (Table 4-17 and Figure 4-18). In conclusion Heterogeneous texture is the characteristics of cases with adenoma and hyperparathyroidism cases (Table 18 and Figure 19).

5-2 Conclusion

The main objective of this study was to characterize the parathyroid using ultrasound and nuclear medicine imaging for 50 patients suffering from Adenoma, hyperparathyroidism, renal disease and hypercalima. The results showed that the abnormality mostly affected female with older age above 50 years and the common type of abnormality was adenoma and hyperparathyroidism. The predominant features were hypoechoic appearance with Heterogeneous pattern. In summary ultrasound and nuclear medicine together they can give a complete description and characterization of parathyroid gland concerning the appearance, uptake, focal lesion status and the common site of the lesion.

5-3 Recommendations

- All patient underwent nuclear medicine examination of parathyroid should be examined by ultrasound.
- Other abnormality concerning parathyroid should be investigate in further study for full description of the diseases concerning parathyroid.
- Further study could be done to compare the counts of the uptake with the size of the parathyroid size
- Also studies could be done to compare the uptake values of different types of abnormality to use it as quantitative characteristics.

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Appendix

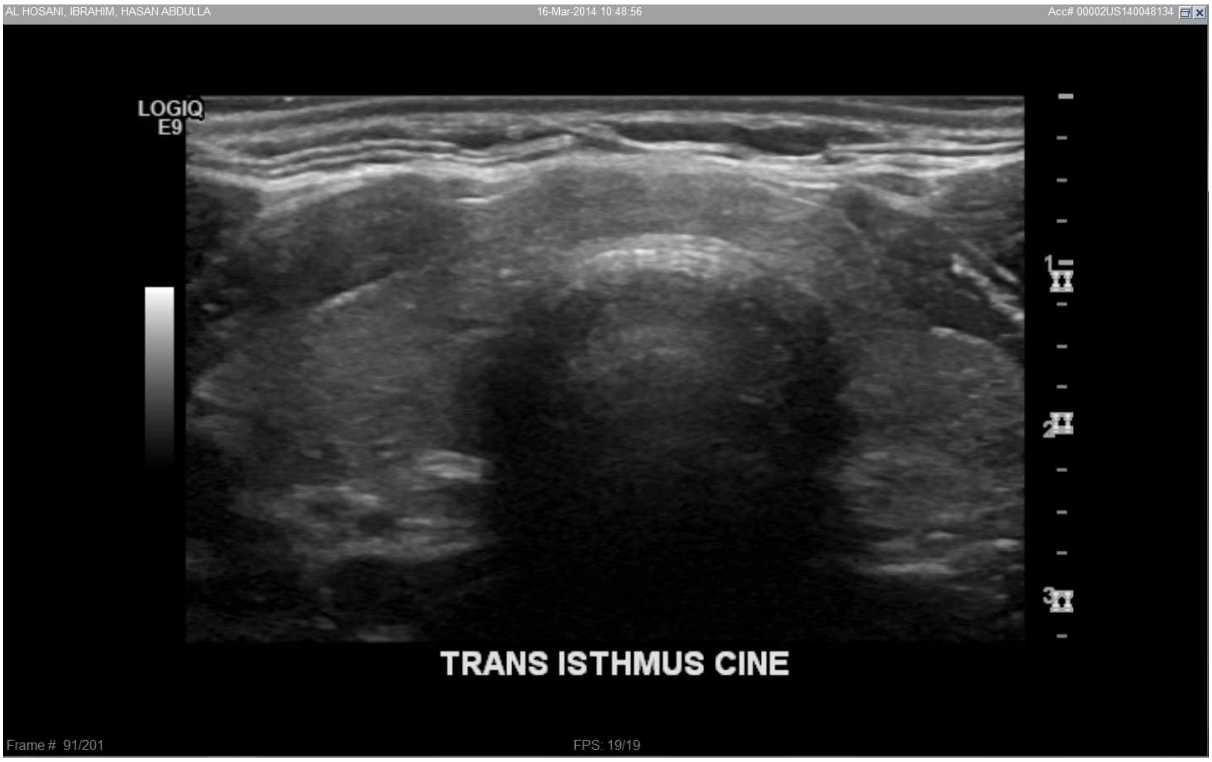

Figure A-1 ultrasound image shows thyroid and parathyroid

Figure A-2 ultrasound image shows thyroid and parathyroid

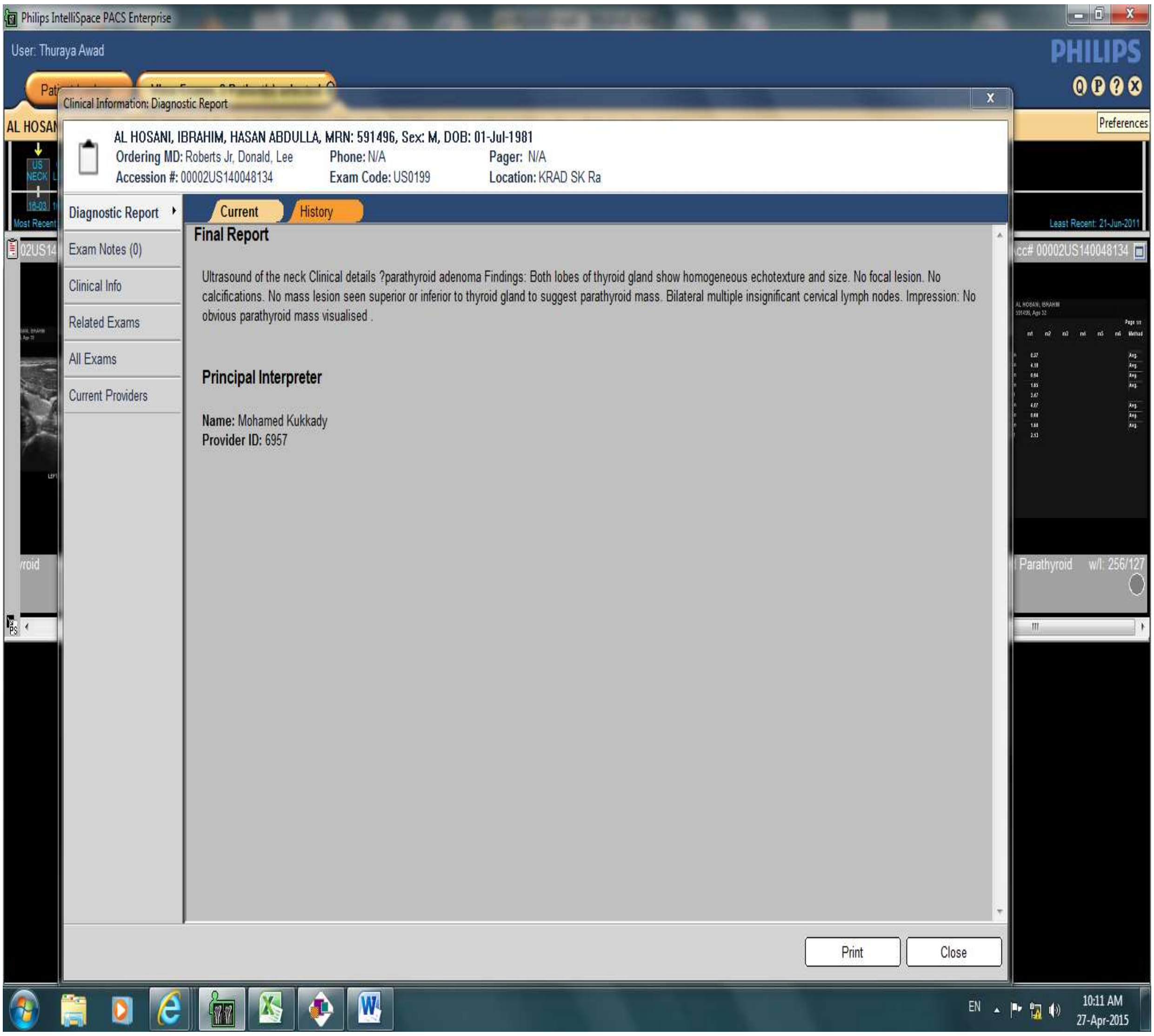

Figure A-3 ultrasound report for figure A-1 and A-2

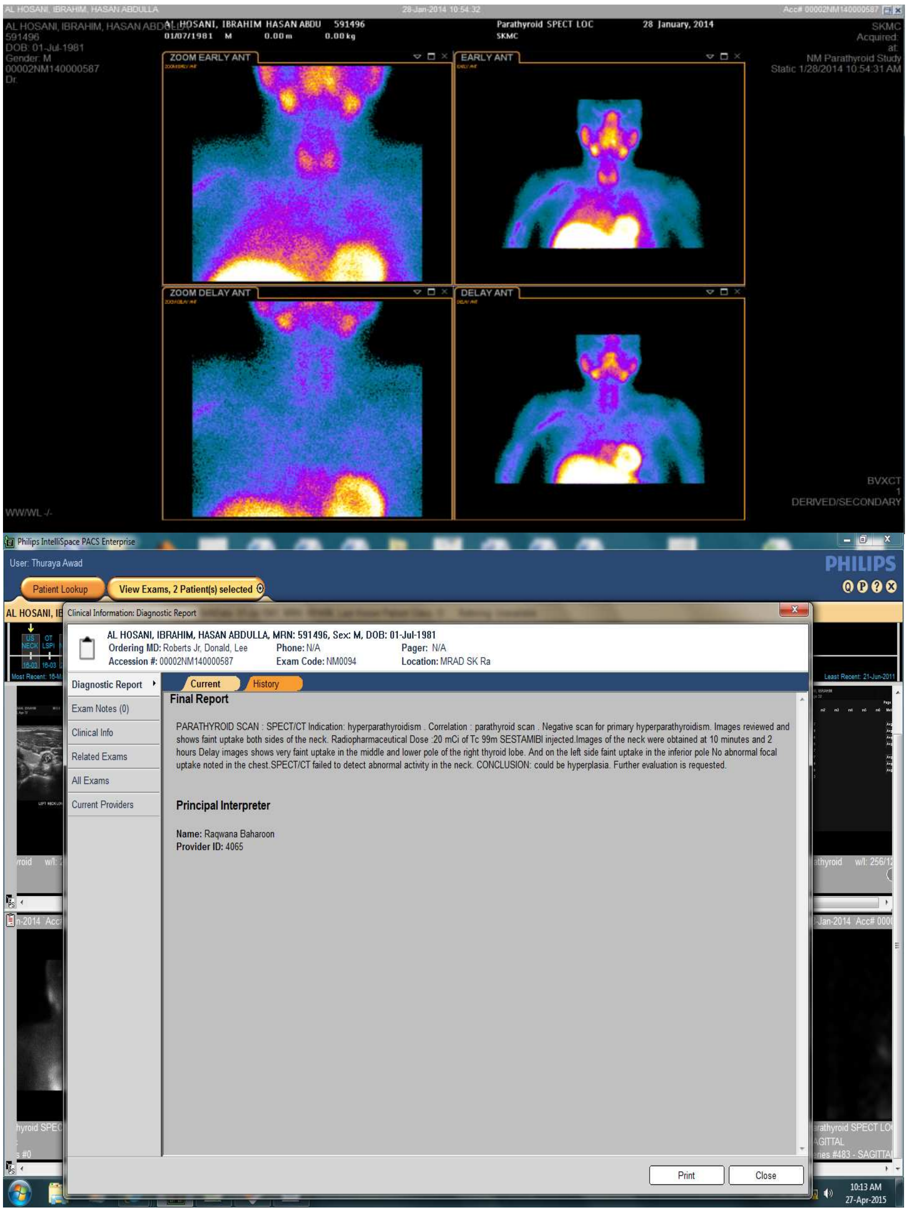

Figure A-4 scintigraphy image result and report

Figure A-5 Scintigraphy scan results for thyroid and parathyroid gland including report