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Characterization of Normal Adrenal Gland in Sudanese Population by Using Computed Tomography

توصيف الغدة الكظرية الطبيعية لدى السودانيين بإستخدام الأشعة المقطعية

A thesis submitted in partial fulfillment for the award of M.Sc degree in Diagnostic Radiologic Technology

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2015

الآيـــة

قال تعالي:

(قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ)

سورة البقرة (32)

Dedication

This work is nicely dedicated to my family and my friends.

Acknowledgement

I would like to extend thanks to the people who so generously contributed to the work presented in this thesis.

First and foremost, I would like to thank my supervisor, A. Salah Ali Fadlalla, for his assistance, ideas, and feedbacks during the process in doing this thesis.

Secondly, it is a pleasure to express my thanks to all colleagues in Antalya Medical Center, and Military hospital for sparing their time to participate in this study. I deeply appreciate their helpfulness and willingness in providing the useful information for this study.

Lastly, I wish to express my sincere gratitude to my wife and family for their encouragement and spiritual support.

Abstract

The adrenal gland is, despite her small size, among the most important and vital organs in the human body.

The purpose of this study was to characterize the normal adrenal gland's location, shape, texture and size and correlate that with gender and age in Sudanese population by using computed tomography.

The study was performed during the period from August 2015 to September 2015 in CT departments of Antalya Medical Center and Military hospital.

The data were collected from randomly selected sample of 50 patients (21 males and 29 females) who underwent CT abdomen for other indications without evidence of adrenal diseases.

The main findings of correlations included that most common shape of the adrenal gland was linear, and when correlating the normal texture and size of the adrenal gland with the age and gender, it was found that texture and size of the adrenal gland decreased with age, and the size of the adrenal gland in females was smaller as compared to males.

الملخص

الغدة الكظرية بالرغم من صغر حجمها تعتبر من الأعضاء المهمة والحيوية في جسم الإنسان.

الغرض من هذه الدراسة توصيف موقع وشكل وطبيعة وحجم الغدة الكظرية الطبيعية للسودانيين ومقارنته بالعمر والجنس باستخدام الأشعة المقطعية.

أجريت هذه الدراسة في الفترة من أغسطس 2015م وحتى سبتمبر 2015م بقسم الأشعة المقطعية في مركز انطاليا الطبي بالخرطوم ومستشفي السلاح الطبي بام درمان.

أخذت البيانات من عينة عشوائية تتكون من 50 مريضاً (21 من الرجال و 29 من النساء) خضعوا لفحص أشعة مقطعية للبطن لأسباب أخري غير أمراض الغدة الكظرية.

خلصت نتائج الدراسة المتعلقة بالارتباط إلي أن الشكل الخطي للغدة الكظرية هو الأكثر شيوعاً.وبعد مقارنة طبيعة وحجم الغدة الكظرية الطبيعية مع العمر والجنس وجد أن طبيعة وحجم الغدة الكظرية الطبيعية يتناقص بازدياد العمر وان حجم الغدة الكظرية عند النساء اصغر عند مقارنتها بالرجال.

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List of abbreviations

ACTH	Adrenocorticotropic hormone.
ADC	Analog to digital converter.
CAH	Congenital adrenal hyperplasia.
CRH	Corticotropin releasing hormone.
CT	Computed tomography.
DAS	Data-acquisition system.
GB	Gall bladder.
GE	General electric.
HU	Hounsfield unit.
Lt	Left.
MRI	Magnetic resonance imaging.
PET	Positron emission tomography.
Rt	Right.
SPSS	Statistical package for the social sciences.
T	Thickness.
US	Ultrasound.
W	Width.
WL	Window level.
WW	Window width.

Contents

Chapter one

Chapter one

1-1 Introduction:

The adrenal glands are two yellowish retroperitoneal organs that lie on the upper poles of the kidneys against the crura of the diaphragm. The left is related anteriorly to the stomach across the lesser sac, the right lies behind the right lobe of the liver and tucks medially behind the inferior vena cava. They are surrounded by renal fascia. Each gland has a yellow cortex and a dark brown medulla. (Richard s. Snell 2012)

The adrenal medulla secrete epinephrine and norepinephrine, which collectively are called catecholamines and are sympathomimetic, and The adrenal cortex secretes three types of steroid hormones: mineralocorticoids, glucocorticoids, and sex hormones. The sex hormones are estrogens "female" and androgens "male". (Valerie C. Scanlon and Tina Sanders, 2007)

Diseases of the adrenal cortex can be conveniently divided into those associated with cortical hyperfunction and those characterized by cortical hypofunction. The most important diseases of the adrenal medulla are neoplasms, which include both neuronal neoplasms (including neuroblastomas and more mature ganglion cell tumors) and neoplasms composed of chromaffin cells (pheochromocytomas). (Kumar, V., & Robbins, S. L., 2007)

The adrenal gland is a common site of disease, and radiology is playing a critical role in not only the detection of adrenal abnormalities but in characterizing them as benign or malignant. The adrenal gland is routinely identified at abdominal CT and MR imaging examinations. CT has become the study of choice to differentiate a benign adenoma from a metastasis in the oncology patient. There are numerous imaging modalities including CT, MR imaging, ultrasonography (US), and nuclear medicine imaging that can be used to evaluate the adrenal but the CT is the primary modality for both detection and characterization of adrenal masses. If an adrenal mass is suspected, CT technique should be tailored to optimize visualization of the adrenal gland. (William W. Mayo-Smith, 2000)

1-2 Problem of the Study:

- Adrenal abnormalities are common and more frequently constitute incidental findings and there are great varieties of the adrenal diseases and their clinical manifestations are complicated and also the deep position of the adrenal glands and their complex relationships with their nearby structures and viscera complicate the clinical analysis of the many diseases affecting the adrenal glands, therefore characterization of the normal anatomical information is needed to facilitate the diagnosis and surgical treatment of adrenal disease.

1-3 Justification:

- The knowledge of the normal variation in location, shape, texture and size of the normal adrenal glands is useful for optimal interpretation of computed tomography scans in patients with adrenal glands pathology.

1-4 Objectives:

1-4-1 General Objective:

- To characterize the normal adrenal glands with Computed Tomography in Sudanese Population.

1-4-2 Specific Objectives:

- To determine the location of both adrenal glands.
- To evaluate the normal shape of both adrenal glands.
- To evaluate the normal texture of both adrenal glands.
- To measure the length, width and thickness of adrenal glands.
- To evaluate the normal size of the adrenal glands.
- To correlate the normal adrenal gland’s texture and size with gender and age.

1-5 The contents of the study:

The study contain five chapters:

- Chapter One: A general introduction, which consists of an introduction, problem of the study, justification and objectives.
- Chapter Two: The literature review and previous studies.
- Chapter Three: Materials and methods.
- Chapter Four: Results.
- Chapter Five: Discussion, Conclusion and recommendations.
  References – Appendix.

Chapter two

Literature review

Chapter two

2-1 Anatomy:

The adrenal glands has a yellow cortex and a dark brown medulla. The cortex of the adrenal glands secretes hormones that include mineral corticoids, which are concerned with the control of fluid and electrolyte balance; glucocorticoids, which are concerned with the control of the metabolism of carbohydrates, fats, and proteins; and small amounts of sex hormones, which probably play a role in the prepubertal development of the sex organs. The medulla of the adrenal glands secretes the catecholamine's epinephrine and nor epinephrine. (Richard s. Snell 2012)

The right adrenal gland is pyramid shaped and caps the upper pole of the right kidney. It lies behind the right lobe of the liver and extends medially behind the inferior vena cava. It rests posteriorly on the diaphragm. The left adrenal gland is crescentic in shape and extends along the medial border of the left kidney from the upper pole to the hilus. It lies behind the pancreas, the lesser sac, and the stomach and rests posteriorly on the diaphragm. (Richard s. Snell 2012)
Each gland has three arteries supplying it include a direct branch from the aorta, a branch from the phrenic artery and a branch from the renal artery. The single main vein drains from the hilum of the gland into the nearest available vessel—the inferior vena cava on the right, the renal vein on the left.(Harold Ellis, 2006)
The lymph drains into the lateral aortic nodes. Preganglionic sympathetic fibers derived from the splanchnic nerves supply the glands. Most of the nerves end in the medulla of the gland. (Richard s. Snell 2012)

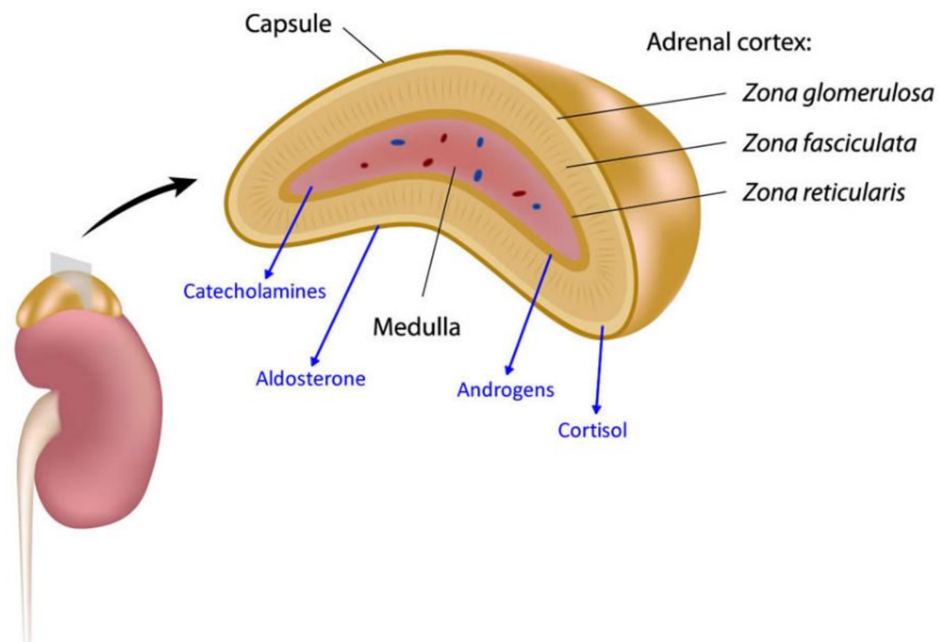

Figure 2-1: The adrenal gland.

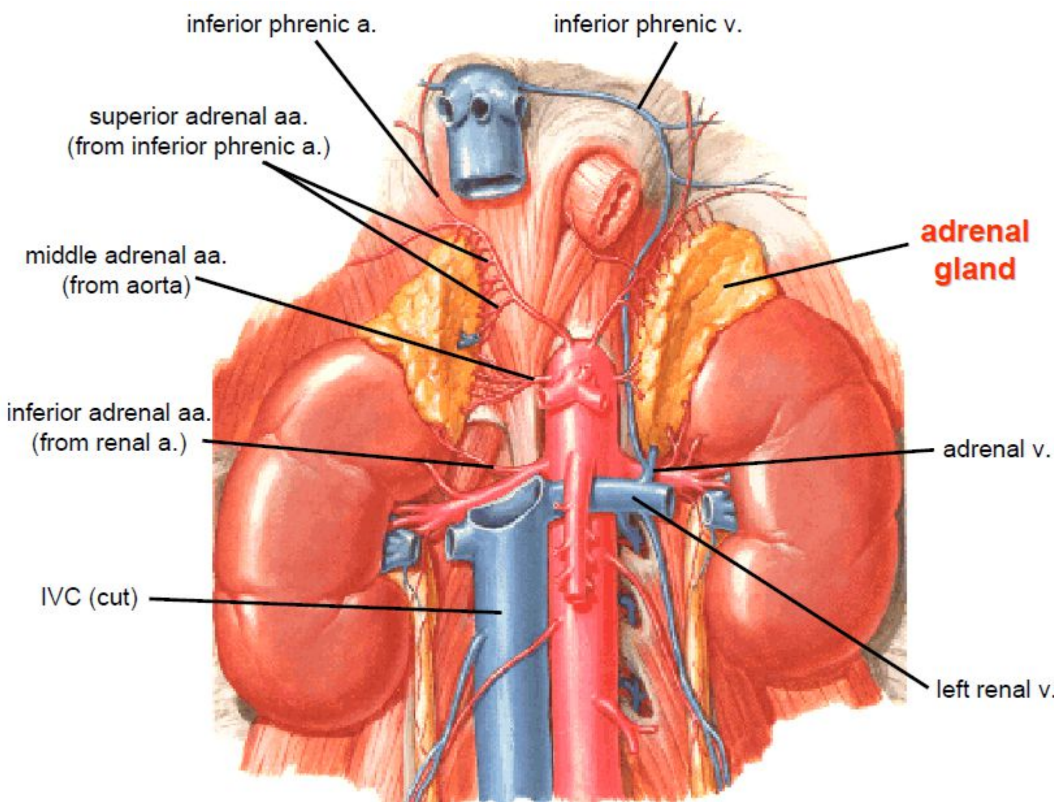

Figure 2-2: The adrenal gland vascular supply and relations.

2-2 Physiology:

The two adrenal glands are located one on top of each kidney, which gives them their other name of suprarenal glands. Each adrenal gland consists of two parts: an inner adrenal medulla and an outer adrenal cortex. The hormones produced by each part have very different functions.

2-2-1 Adrenal medulla:

The cells of the adrenal medulla secrete epinephrine and norepinephrine. The secretion of both hormones is stimulated by sympathetic impulses from the hypothalamus, and their functions duplicate and prolong those of the sympathetic division of the autonomic nervous system.

Epinephrine (Adrenalin) and norepinephrine (noradrenalin) are both secreted in stress situations and help prepare the body for "fight or flight." Norepinephrine is secreted in small amounts, and its most significant function is to cause vasoconstriction in the skin, viscera, and skeletal muscles (that is, throughout the body), which raises blood pressure. Epinephrine, secreted in larger amounts, increases the heart rate and force of contraction and stimulates vasoconstriction in skin and viscera and vasodilation in skeletal muscles. It also dilates the bronchioles, decreases peristalsis, stimulates the liver to change glycogen to glucose, increases the use of fats for energy, and increases the rate of cell respiration. Epinephrine is actually more effective than sympathetic stimulation, however, because the hormone increases energy production and cardiac output to a greater extent. (Valerie C. Scanlon and Tina Sanders, 2007)

2-2-2 Adrenal cortex:

The adrenal cortex secretes three types of steroid hormones: mineralocorticoids, glucocorticoids, and sex hormones. The sex hormones, estrogens "female" and androgens "male", are produced in very small amounts, and their importance is not known with certainty. They may contribute to rapid body growth during early puberty. They may also be important in supplying estrogen to women after menopause and to men throughout life. The functions of the other adrenal cortical hormones are well known, however, and these are considered vital hormones. (Valerie C. Scanlon and Tina Sanders, 2007)

The mineralocorticoids have gained this name because they especially affect the electrolytes (the "minerals") of the extracellular fluids-sodium and potassium, in particular. The glucocorticoids have gained their name because they exhibit important effects that increase blood glucose concentration. They have additional effects on both protein and fat metabolism that are equally as important to body function as their effects on carbohydrate metabolism. More than 30 steroids have been isolated from the adrenal cortex, but two are of exceptional importance to the normal endocrine function of the human body: aldosterone, which is the principal mineralocorticoid, and cortisol, which is the principal glucocorticoid. (Arthur C. Guyton and John E. Hall, 2006)

Aldosterone is the most abundant of the mineralocorticoids. The target organs of aldosterone are the kidneys, but there are important secondary effects as well. Aldosterone increases the reabsorption of sodium and the excretion of potassium by the kidney tubules. Sodium ions (Na_) are returned to the blood, and potassium ions (K_) are excreted in urine. A number of factors stimulate the secretion of aldosterone. These are a deficiency of sodium, loss of blood or dehydration that lowers blood pressure, or an elevated blood level of potassium. Low blood pressure or blood volume activates the rennin angiotensin mechanism of the kidneys. Angiotensin II causes vasoconstriction and stimulates the secretion of aldosterone by the adrenal cortex. Aldosterone then increases sodium and water retention by the kidneys to help restore blood volume and blood pressure to normal. (Valerie C. Scanlon and Tina Sanders, 2007)

Cortisol is responsible for most of the actions of glucocorticoids hormones group. It increases the use of fats and excess amino acids (gluconeogenesis) for energy and decreases the use of glucose. This is called the glucose sparing effect, and it is important because it conserves glucose for use by the brain. Cortisol is secreted in any type of physiological stress situation: disease, physical injury, hemorrhage, fear or anger, exercise, and hunger. Although most body cells easily use fatty acids and excess amino acids in cell respiration, brain cells do not, so they must have glucose. By enabling other cells to use the alternative energy sources, cortisol ensures that whatever glucose is present will be available to the brain. Cortisol also has an anti-inflammatory effect. Too much cortisol, however, decreases the immune response, leaving the body susceptible to infection and significantly slowing the healing of damaged tissue. The direct stimulus for cortisol secretion is ACTH from the anterior pituitary gland, which in turn is stimulated by corticotropin releasing hormone (CRH) from the hypothalamus. CRH is produced in the physiological stress situations mentioned earlier. (Valerie C. Scanlon and Tina Sanders, 2007)

2-3 Pathology:

2-3-1Adrenal cortex:

Diseases of the adrenal cortex can be conveniently divided into those associated with cortical hyperfunction and those characterized by cortical hypofunction.

There are three distinctive hyperadrenal clinical syndromes: (1) Cushing syndrome, characterized by an excess of cortisol; (2) hyperaldosteronism; and (3) adrenogenital or virilizing syndromes, caused by an excess of androgens. The clinical features of some of these syndromes overlap somewhat because of the overlapping functions of some of the adrenal steroids. The most common cause of hypercortisolism is exogenous administration of steroids. Endogenous hypercortisolism is most often secondary to an ACTH-producing pituitary micro-adenoma ("Cushing disease"), followed by primary adrenal neoplasms ("ACTH-independent" hypercortisolism), and paraneoplastic ACTH production by tumors (e.g., small-cell lung cancer).The morphologic features in the adrenal include bilateral cortical atrophy (in exogenous steroid-induced disease), bilateral diffuse or nodular hyperplasia (most common finding in endogenous Cushing syndrome), or an adrenocortical neoplasm. (Kumar, V., & Robbins, S. L., 2007)

Excessive levels of aldosterone cause sodium retention and potassium excretion, with resultant hypertension and hypokalemia. Hyperaldosteronism may be primary, or it may be secondary to an extra-adrenal cause. In secondary hyperaldosteronism, aldosterone release occurs in response to activation of the renin-angiotensin system. It is characterized by increased levels of plasma renin and is encountered in conditions associated with: Decreased renal perfusion (arteriolar nephrosclerosis, renal artery stenosis) Arterial hypovolemia and edema (congestive heart failure, cirrhosis, nephrotic syndrome) Pregnancy (caused by estrogen-induced increases in plasma renin substrate). (Kumar, V., & Robbins, S. L., 2007)

The adrenal cortex can secrete excess androgens in two settings: adrenocortical neoplasms (usually "virilizing" carcinomas) or congenital adrenal hyperplasia (CAH).CAH is a group of autosomal recessive disorders characterized by defects in steroid biosynthesis, usually cortisol; the common subtype is caused by deficiency of the enzyme 21-hydroxylase.Reduction in cortisol production causes a compensatory increase in ACTH secretion, which in turn stimulates androgen production. Androgens have virilizing effects, including masculinization in females (ambiguous genitalia, oligomenorrhea, and hirsutism), precocious puberty in males and in some instances, salt (sodium) wasting and hypotension. There is bilateral hyperplasia of the adrenal cortex, and a subset of 21-hydroxylase-deficient patients also demonstrates "adrenomedullary dysplasia." (Kumar, V., & Robbins, S. L., 2007)

Adrenocortical insufficiency, or hypofunction, may be caused by either primary adrenal disease (primary hypoadrenalism) or decreased stimulation of the adrenals resulting from a deficiency of ACTH (secondary hypoadrenalism). The patterns of adrenocortical insufficiency can be considered under the following headings: (1) primary acute adrenocortical insufficiency (adrenal crisis), (2) primary chronic adrenocortical insufficiency (Addison disease), and (3) secondary adrenocortical insufficiency. (Kumar, V., & Robbins, S. L., 2007)

It should be evident from the discussion of adrenocortical hyperfunction that functional adrenal neoplasms may be responsible for any of the various forms of hyperadrenalism. While functional adenomas are most commonly associated with hyperaldosteronism and with Cushing syndrome, a virilizing neoplasm is more likely to be a carcinoma. However, not all adrenocortical neoplasms elaborate steroid hormones. Determination of whether a cortical neoplasm is functional or not is based on clinical evaluation and measurement of the hormone or its metabolites in the laboratory. In other words, functional and nonfunctional adrenocortical neoplasms cannot be distinguished on the basis of morphologic features. (Kumar, V., & Robbins, S. L., 2007)

2-3-2 Adrenal medulla:

The most important diseases of the adrenal medulla are neoplasms, which include both neuronal neoplasms (including neuroblastomas and more mature ganglion cell tumors) and neoplasms composed of chromaffin cells (pheochromocytomas). Pheochromocytomas are neoplasms composed of chromaffin cells, which, like their non-neoplastic counterparts, synthesize and release catecholamines and, in some cases, other peptide hormones. These tumors are of special importance because, although uncommon, they (like aldosterone-secreting adenomas) give rise to a surgically correctable form of hypertension. (Kumar, V., & Robbins, S. L., 2007)

Neuroblastoma is the most common extra-cranial solid tumor of childhood. These neoplasms occur most commonly during the first 5 years of life and may arise during infancy. Neuroblastomas may occur anywhere in the sympathetic nervous system and occasionally within the brain, but they are most common in the abdomen; most cases arise in either the adrenal medulla or the retroperitoneal sympathetic ganglia. Most neuroblastomas are sporadic, although familial cases also occur.

(Kumar, V., & Robbins, S. L., 2007)

2-4 CT machine:

CT scanners are complex, with many different components involved in the process of creating an image. Adding to the complexity, different CT manufacturers often modify the design of various components. From a broad perspective, all makes and models of CT scanners are similar in that they consist of a scanning gantry, x-ray generator, computer system, operator's console, and physician's viewing console. Although hard-copy filming has largely been replaced by workstation viewing and electronic archiving, most CT systems still include a laser printer for transferring CT images to film. **(**Lois E. Romans, 2011)

The three major components of a CT imaging system are the operating console, the computer, and the gantry. Each of these major components has several subsystems.

Computed tomography imaging systems can be equipped with two or three consoles. One console is used by the CT radiologic technologist to operate the imaging system. Another console may be available for a technologist to postprocess images to annotate patient data on the image (e.g., hospital identification, name, patient number, age, gender) and to provide identification for each image (e.g., number, technique, couch position). This second monitor also allows the operator to view the resulting image before transferring it to the physician's viewing console.

A third console may be available for the physician to view the images and manipulate image contrast, size, and general visual appearance. This is in addition to several remote imaging stations. (Stewart Carlyle Bushong, 2013)

The computer is a unique subsystem of the CT imaging system. Depending on the image format, as many as 250,000 equations must be solved simultaneously; thus, a large computing capacity is required. Many CT imaging systems use an array processor instead of a microprocessor for image reconstruction. The array processor does many calculations simultaneously and hence is significantly faster than the
microprocessor. (Stewart Carlyle Bushong, 2013)

The gantry includes the x-ray tube, the detector array, the high-voltage generator, the patient support couch, and the mechanical support for each. These subsystems receive electronic commands from the operating console and transmit data to the computer for image production and postprocessing tasks. (Stewart Carlyle Bushong, 2013)

X-ray tubes produce the x-ray photons that create the CT image. Their design is a modification of a standard rotating anode tube, such as the type used in angiography. Tungsten, with an atomic number of 74, is often used for the anode target material because it produces a higher-intensity x-ray beam. CT tubes often contain more than one size of focal spot; 0.5 and 1.0 mm are common sizes. Early CT scanners used recoiling system cables to rotate the gantry frame. Current systems use electromechanical devices called slip rings. Slip rings use a brushlike
apparatus to provide continuous electrical power and electronic communication across a rotating surface. They permit the gantry frame to rotate continuously, eliminating the need to straighten twisted system cables. (Lois E. Romans, 2011)

As the x-ray beam passes through the patient it is attenuated to some degree. To create an x-ray image we must collect information regarding the degree to which each anatomic structure attenuated the beam. In CT, detectors used to collect the information. the detector array comprises detector elements situated in an arc or a ring, each of which measures the intensity of transmitted x-ray radiation along a beam projected from the x-ray source to that particular detector element. Detectors can be made from different substances, each with their own advantages and disadvantages. All new scanners possess detectors of the solid-state crystal variety. Detectors made from xenon gas have been manufactured but have largely become obsolete as their design prevents them from use in MDCT systems. **(**Lois E. Romans, 2011)

High-frequency generators are currently used in CT. They are small enough so that they can be located within the gantry.

Generators produce high voltage and transmit it to the x-ray tube. CT generators produce high kV (generally 120–140 kV) to increase the intensity of the beam, which will increase the penetrating ability of the x-ray beam and thereby reduce patient dose. In addition, a higher kV setting will help to reduce the heat load on the x-ray tube by allowing a lower mA setting. Reducing the heat load on the x-ray tube will extend the life of the tube. **(**Lois E. Romans, 2011)

The patient lies on the table (or couch, as it is referred to by some manufacturers) and is moved within the gantry for scanning. The process of moving the table by a specified measure is most commonly called incrementation, but is also referred to as feed, step, or index. Helical CT table incrementation is quantified in millimeters per second because the table continues to move throughout the scan. The degree to which a table can move horizontally is called the scannable range, and will determine the extent a patient can be scanned without repositioning. The specifications of tables vary, but all have certain weight restrictions. On most scanners, it is possible to place the patient either head first or feet first, supine or prone. Patient position within the gantry depends on the examination being performed. **(**Lois E. Romans, 2011)

Figure 2-3: The gantry and patient table are major components of a CT image system.

2-5 Previous studies:

In this study done by Jean Philippe Montagne, scans of 60 random patients who had sections obtained at 1 cm intervals through the region of both adrenal glands were reviewed. None of the patients had clinical evidence of adrenal disease. The 33 men and 27 women ranged in age from 27 to 80 years (mean 56 years). An EMI 5000 body scanner (matrix size 160 **x** 160) produced 48 of the scans; a General Electric CT/T Body Scanner (matrix size 320 **x** 320) was used for the other 12. The presence, location, size, and shape of both adrenal glands were evaluated. Measurements were made on the hard copy recording medium routinely used in our department for each scanner. The measurements were made to the nearest millimeter and then multiplied by the appropriate magnification factor to obtain the true size. This method resulted in corrected measurements to the nearest 0.5 cm. The length of the gland was defined as its cephalocaudal dimension and the width as the greatest linear dimension seen on any single tomographic section. The thickness of the adrenal gland was defined as its dimension perpendicular to the long axis of the gland or one of its limbs. The greatest thickness at any site was the measurement recorded. In the linear glands this tended to occur at the anterior portion, while in the V- and Y-shaped glands the site was usually at the junction of the limbs. Thickness was not measured in triangular-shaped glands because a long axis could not be defined. In 47 of the 60 patients (78%) both adrenal glands were delineated cleanly enough to perform the measurements. In 13 patients (22%) both adrenal glands were either not seen or inadequately seen to determine their size and shape. (Jean-Philippe Montagne, Herbert y. Kressel, Melvyn korobkin, and Albert A. Moss, 1978)

Another study done by Vincent JM1, the aim of the study was to determine the size of normal adrenal glands. Measurements of the adrenal glands were obtained from computed tomographic (CT) images in 55 patients already undergoing CT for routine clinical indications. Patients with conditions known to affect the size of adrenal glands or cases with focal adrenal enlargement suggesting a mass were excluded. The following dimensions were measured: the maximum width perpendicular to the long axis of the body of the gland, and maximum width of the medial and lateral limbs. The average measurements for the right adrenal gland were: maximum width 0.61 cm (S.D. 0.2), width of the medial limb 0.28 cm (S.D. 0.08), and width of the lateral limb 0.28 cm (S.D. 0.06). The average measurements for the left adrenal gland were: maximum width 0.79 cm (S.D. 0.21), width of the medial limb 0.33 cm (S.D. 0.09), and width of the lateral limb 0.30 cm (S.D. 0.10). **(**Vincent JM1, Morrison ID, Armstrong P, Reznek RH, 1994**)**

Chapter three

Materials and Methods

Chapter three

Materials and Methods

3-1 Materials

3-1-1 Study sample

This study is a descriptive study.
Random selection sample of 50 patients (21 males and 29 females), and whose ages ranged between 30 and 69(Mean 47 years) underwent CT abdomen for other indications without evidence of adrenal diseases.

3-1-2 Study area and Duration

The study carried out in Antalya Medical Center, Military hospital.
This study carried out in two months.

3-1-3 Equipments

The CT machines used in this study were GE (Bright Speed S - CT99) in Antalya Medical Center and Toshiba Aquilion 64 slices in Military hospital.

Figure 3-1: CT machine in Antalya Medical Center (GE).

Figure 3-2: CT machine in Military hospital (Toshiba Aquilion 64 slices).

3-2 Methods

3-2-1 Technique used

Scout: AP, Reference landmark.

Scan mode: Spiral.

I.V. Contrast: 3.3 ml/sec, Volume: 75-90 ml.

Scan delay: 35 sec.

Oral contrast: 300 ml 2 hours before scan.200 ml just before scan.

Breath hold: Suspended expiration.

Slice thickness: 5mm.

3-2-2 Image interpretation

The data obtained from serial axial and reformatted coronal and sagittal sections of CT abdomen images of patients., references, previous studies and internet.
The data analysis statistically using SPSS.

3-2-3 Measurements of the adrenal glands

The shape of the gland was determined on the section where the gland was best seen.
The length of each adrenal gland was estimated by counting the number of transverse cross sections on which each was visualized.
The width of each gland was determined on the section in which the adrenal appeared largest during the examination.
Thickness of the glands measured was determined on the section as shown in Figure 3-4.

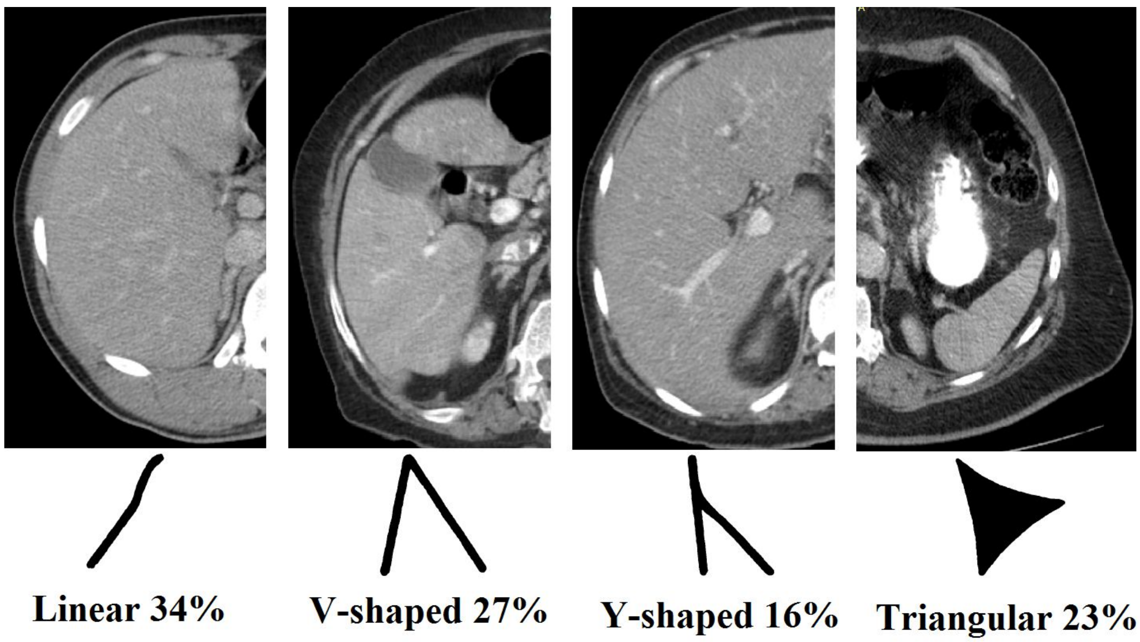

Figure 3-3: Shows the shapes of the gland configurations on each cross section.

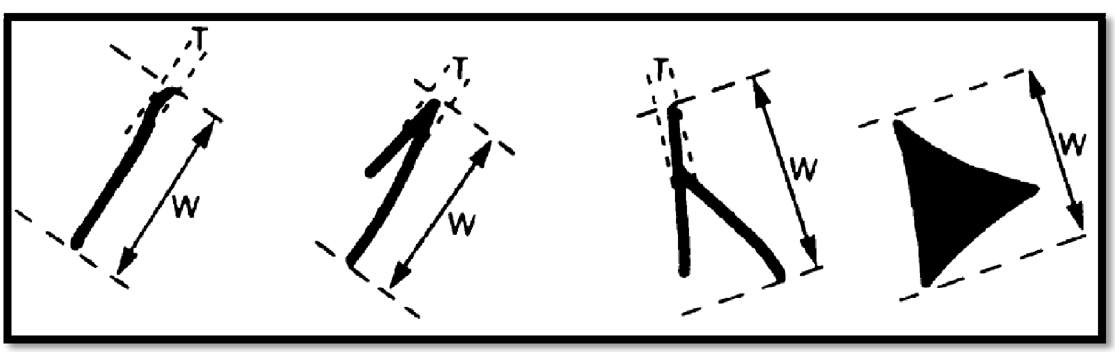

Figure 3-4: shows the methods used to measure the width (W) and thickness (T) of the normal adrenal glands.

Chapter four

Results

Chapter four

Results

The following tables and figures represent data obtained from randomly selected sample of 50 patients (21 males and 29 females) who underwent CT abdomen for other indications without evidence of adrenal diseases.

Table 4-1: Study group gender distribution.

Gender	Frequency	Percentage %
Male	**21**	**42%**
Female	**29**	**58%**
Total	**50**	**100%**

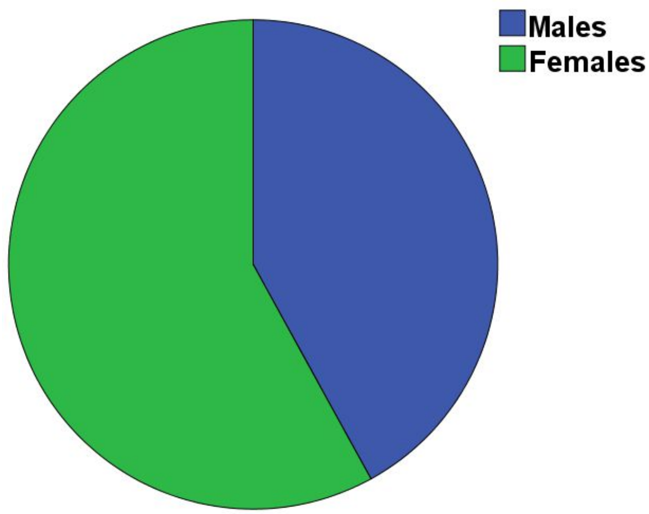

Figure 4-1: Study group Age distribution.

Table 4-2: Study group Age distribution.

Age classes	Male		Female	
	Frequency	Percentage %	Frequency	Percentage %
30-40	**4**	**19%**	**11**	**38%**
41-50	**9**	**43%**	**8**	**28%**
51-60	**4**	**19%**	**8**	**28%**
61-70	**4**	**19%**	**2**	**6%**
Total	**21**	**100%**	**29**	**100%**

Table 4-3: Mean of study group Age.

Gender	Mean
Male	49.67
Female	45.62

Table 4-4: Study group Shape distribution.

Shape	Frequency	Percentage %
Linear	34	34%
V-shaped	27	27%
Y-shaped	16	16%
Triangular	23	23%
Other	0	0%
Total	100	100%

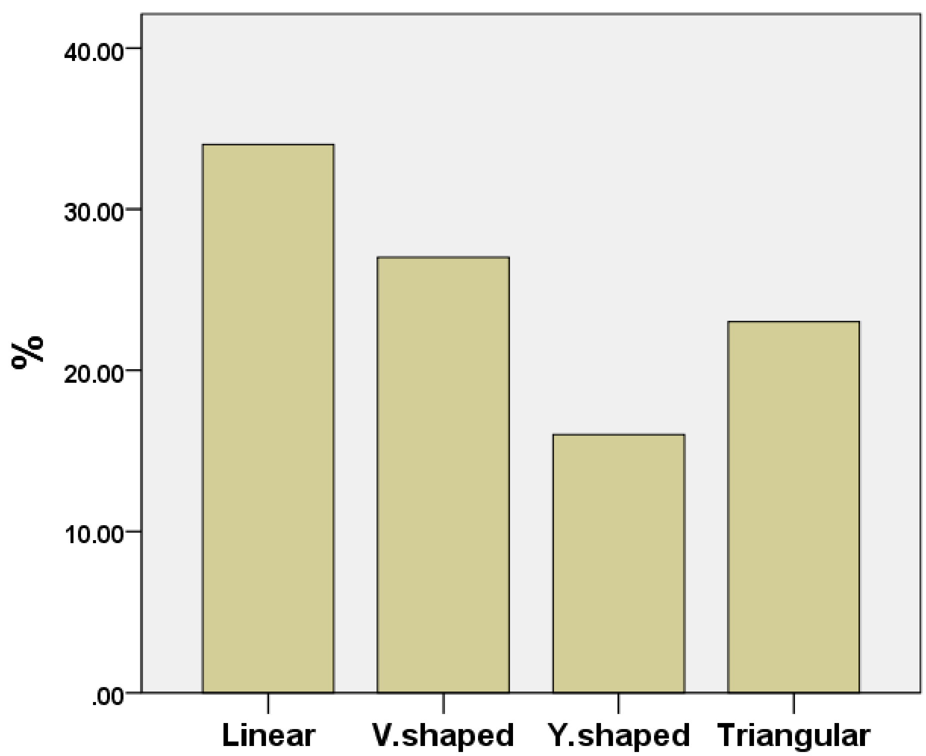

Figure 4-2: Study group Shape distribution.

Table 4-5: Length of right and left adrenal glands.

Number of sections	Right adrenal gland		Left adrenal gland	
	Frequency	%	Frequency	%
8-10	16	32%	7	14%
11-13	14	28%	8	16%
14-16	17	34%	20	40%
17-19	4	8%	12	24%
20	1	2%	1	2%

Slice thickness 2.5 mm.

Table 4-6: Width of right and left adrenal glands.

Centimeter	Right adrenal gland		Left adrenal gland	
	Frequency	%	Frequency	%
1 – 1.9	1	2%	1	2%
2 – 2.9	23	46%	35	70%
3 – 3.9	23	46%	13	26%
4 - 5	3	6%	1	2%

Table 4-7: Thickness of right and left adrenal glands.

Centimeter	Right adrenal gland		Left adrenal gland	
	Frequency	%	Frequency	%
0.5	32	64%	34	68%
0.6	14	28%	10	20%
0.7	4	8%	6	12%

Table 4-8: Right and left adrenal glands measurements Mean.

Adrenal glands measurements Mean	Right adrenal gland				Left adrenal gland			
	Length	Width	Thickness	Size	Length	Width	Thickness	Size
Male	3.14	3.04	0.5	5.24	3.58	2.93	0.5	5.97
Female	3.03	3.04	0.5	5.11	3.74	2.61	0.5	5.35

Table 4-9: Mean of right and left adrenal glands texture.

Adrenal glands texture Mean	Right adrenal gland	Left adrenal gland
Male	24.19	25.00
Female	24.21	24.03

Table 4-10: Correlations between the age and the normal right adrenal gland size.

		Age	Right Adrenal Gland Size
Age	Pearson Correlation	1	-.594-**
	Sig. (2-tailed)		.000
	N	50	50
Right Adrenal Gland Size	Pearson Correlation	-.594-**	1
	Sig. (2-tailed)	.000	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

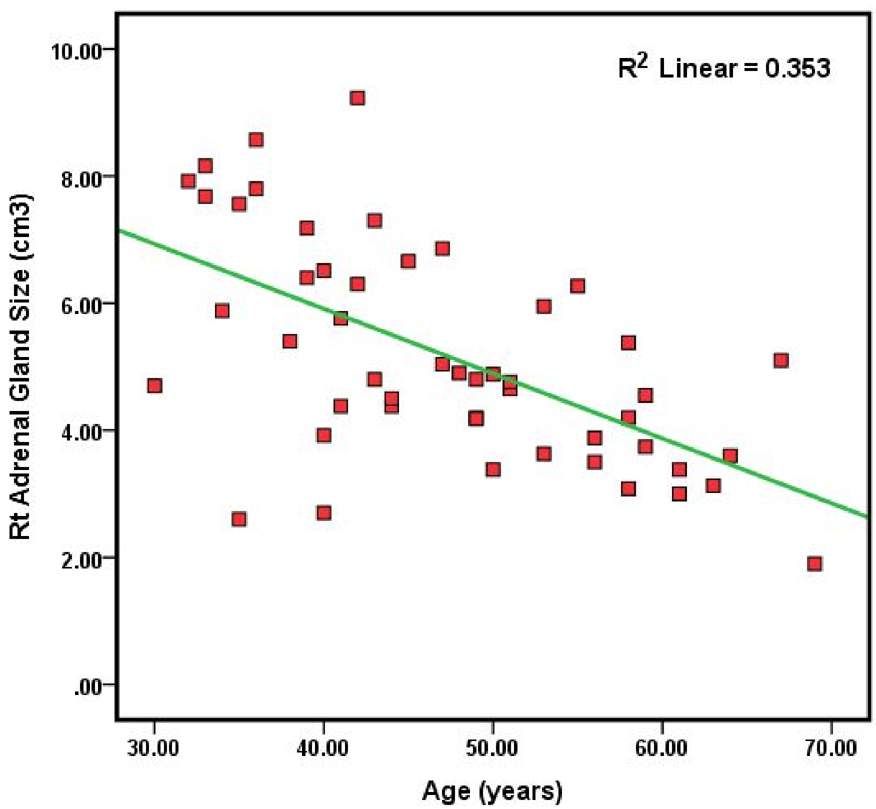

Figure 4-3: Scatter plot diagram shows the correlation between the age and the normal right adrenal gland size.

Table 4-11: Correlations between the age and the normal left adrenal gland size.

		Age	Left Adrenal Gland Size
Age	Pearson Correlation	1	-.472-**
	Sig. (2-tailed)		.001
	N	50	50
Left Adrenal Gland Size	Pearson Correlation	-.472-**	1
	Sig. (2-tailed)	.001	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

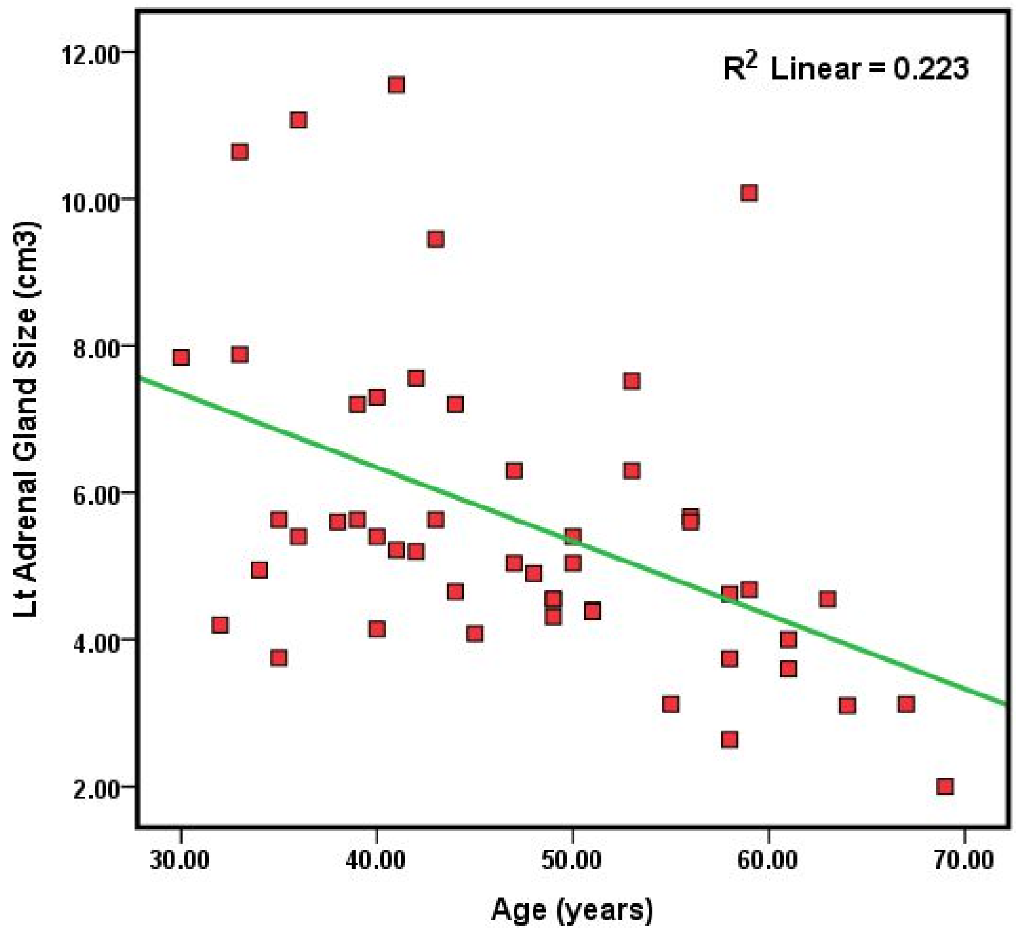

Figure 4-4: Scatter plot diagram shows the correlation between the age and the normal left adrenal gland size.

Table 4-12: Correlations between the age and the normal right adrenal gland texture.

		Age	Right Adrenal Gland Texture
Age	Pearson Correlation	1	-.678-**
	Sig. (2-tailed)		.000
	N	50	50
Right Adrenal Gland Texture	Pearson Correlation	-.678-**	1
	Sig. (2-tailed)	.000	
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

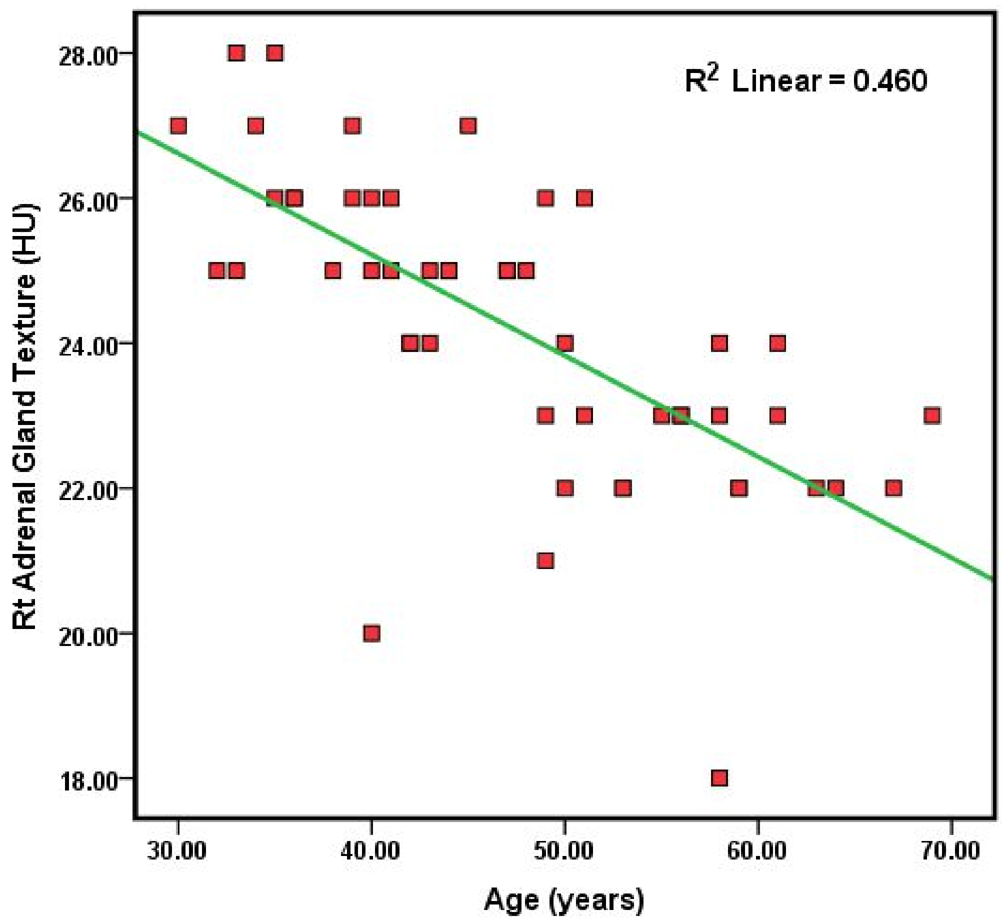

Figure 4-5: Scatter plot diagram shows the correlation between the age and the normal right adrenal gland texture.

Table 4-13: Correlations between the age and the normal left adrenal gland texture.

		Age	Left Adrenal Gland Texture
Age	Pearson Correlation	1	-.322-*
	Sig. (2-tailed)		.023
	N	50	50
Left Adrenal Gland Texture	Pearson Correlation	-.322-*	1
	Sig. (2-tailed)	.023	
	N	50	50

*. Correlation is significant at the 0.05 level (2-tailed).

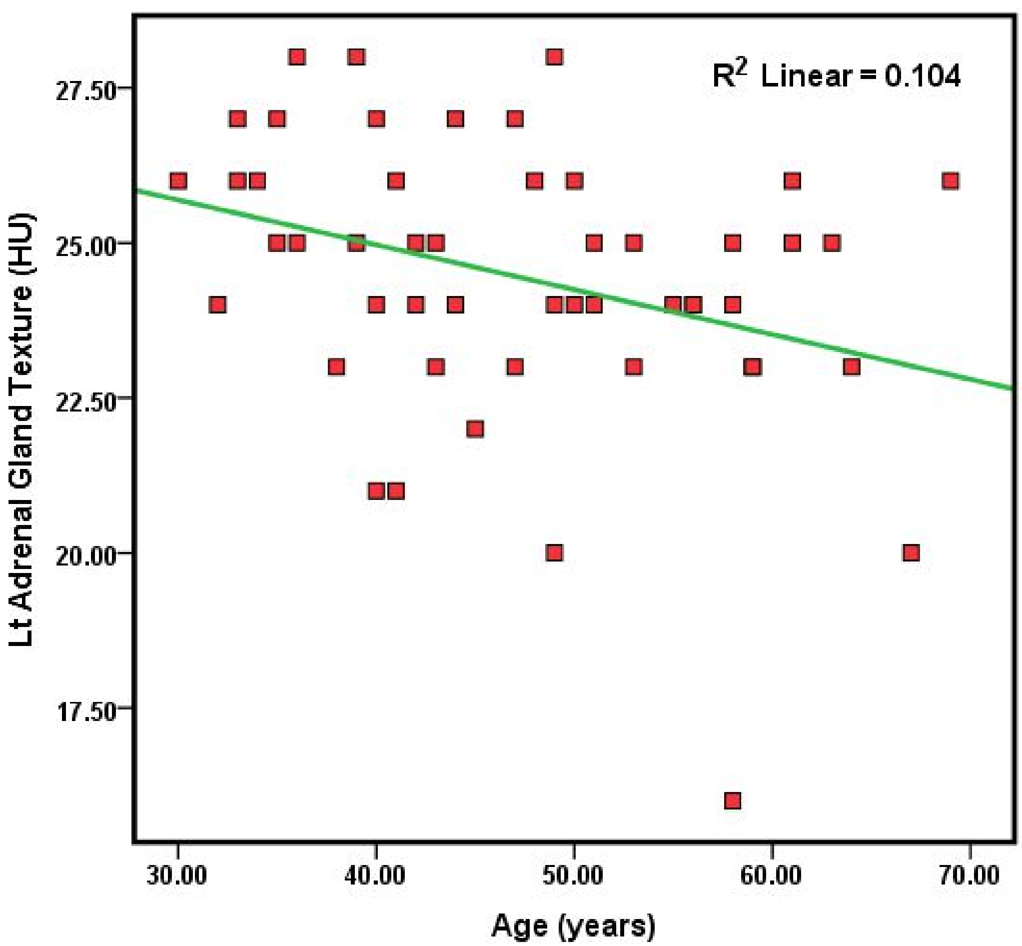

Figure 4-6: Scatter plot diagram shows the correlation between the age and the normal left adrenal gland texture.

Chapter five

Discussion, Conclusion and recommendations

Chapter five

5-1 Discussion

Prior studies characterized the normal adrenal glands using computed tomography. The presence, location, size, and shape of both adrenal glands were evaluated. Measurements were made on the hard copy recording medium. Most frequent shape of normal adrenal glands was linear (87%) in the right gland and V-shaped (50%) in the left gland. The normal adrenal gland's length, width, thickness were 2-4 cm, 2-2.5 cm, 1 cm respectively.(Jean-Philippe Montagne, Herbert y. Kressel, Melvyn korobkin, and Albert A. Moss, 1978)

In this study sample (50 patients), both adrenal glands were delineated clearly enough to perform the measurements of length, width and thickness and determine the shape of the gland.

Both right and left adrenal glands were in their typical locations, the right lies behind the right lobe of the liver and extends medially behind the inferior vena cava and the left lies behind the pancreas, the lesser sac, and the stomach.

The study showed that the most common shape of the normal gland was linear (34%).

The normal adrenal gland's length, width, thickness and size in male right adrenal gland were 3.14 cm, 3.04 cm, 0.5 cm, 5.24 cm3 respectively, and male left adrenal gland were 3.58 cm, 2.93 cm, 0.5 cm, 5.97 cm3 respectively, and female right adrenal gland were 3.03 cm, 3.04 cm, 0.5 cm, 5.11 cm3 respectively, and female left adrenal gland were 3.74 cm, 2.61 cm, 0.5 cm, 5.35 cm3 respectively, and these measurements showed that the size of the adrenal gland in females is smaller as compared to males.

Study showed that there was significant Correlation between age and adrenal gland's size and texture. The right adrenal gland's size decreased by – 0.594 starting from 5.76 cm3 as the age increased and the left adrenal gland's size decreased by – 0.472 starting from 5.40 cm3 as the age increased.

The right adrenal gland's texture decreased by – 0.678 starting from 26 HU as the age increased, and the left adrenal gland's texture decreased by – 0.322 starting from 25 HU as the age increased.

5-2 Conclusion

The researcher concluded that most common shape of the adrenal gland was linear, and the texture and size of the adrenal gland decreased with age, and the size of the adrenal gland in females was smaller as compared to males.

5-3 Recommendations

For further assessment more researches should be done using a large sample of patients.

The researcher recommended that another studies should be done to assess the normal adrenal gland function.

Other study should be done using PET/CT scan.

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Appendices

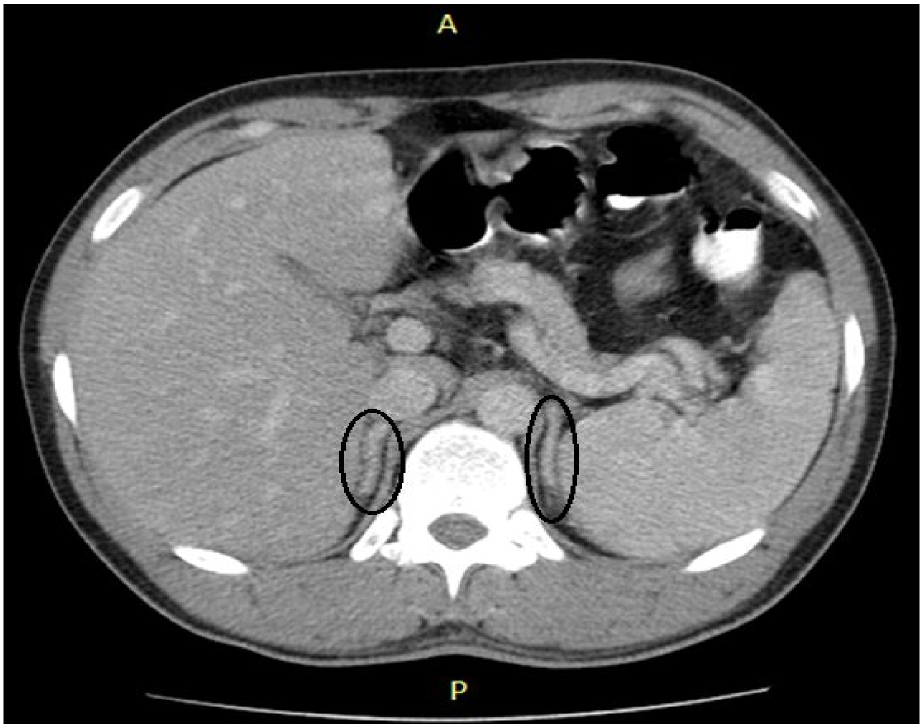

Figure 5-1: Axial CT image for Male (36 years) shows typical location of both right adrenal gland (linear shape) and left adrenal gland (linear shape).

Figure 5-2: Axial CT image for Female (41 years) shows typical location of both right adrenal gland (V shape) and left adrenal gland (Y shape).

Figure 5-3: Axial CT image for Male (50 years) shows typical location of both right adrenal gland (linear shape) and left adrenal gland (triangular shape).

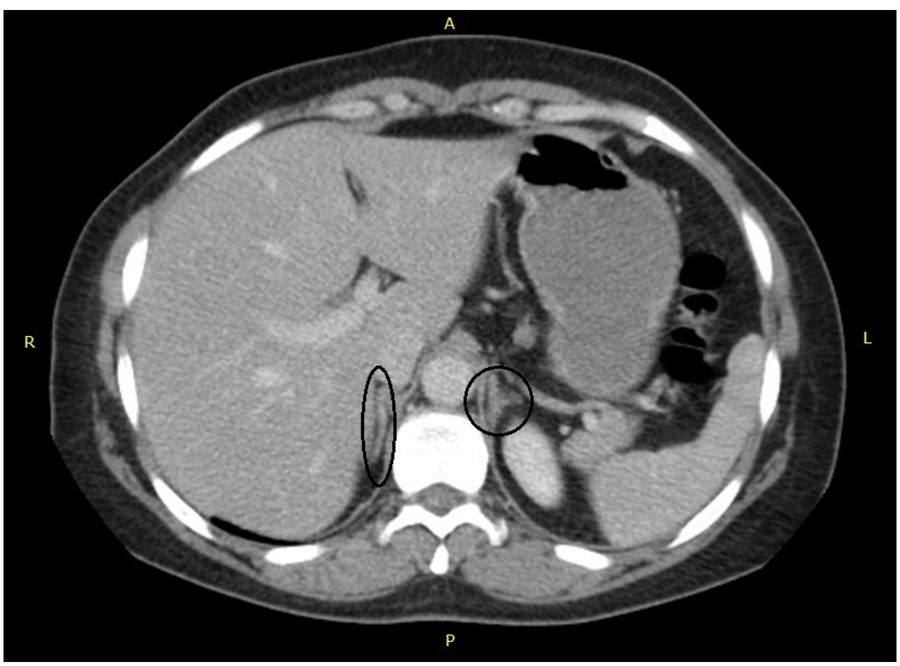

Figure 5-4: Axial CT image for Female (51 years) shows typical location of both right adrenal gland (linear shape) and left adrenal gland (triangular shape).

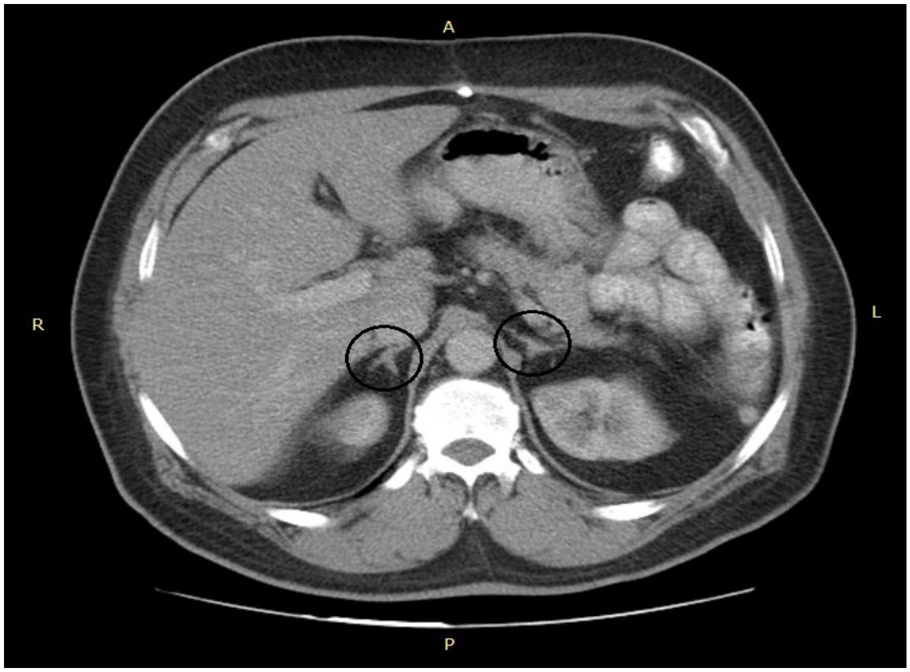

Figure 5-5: Axial CT image for Male (48 years) shows typical location of both right adrenal gland (Y shape) and left adrenal gland (triangular shape).

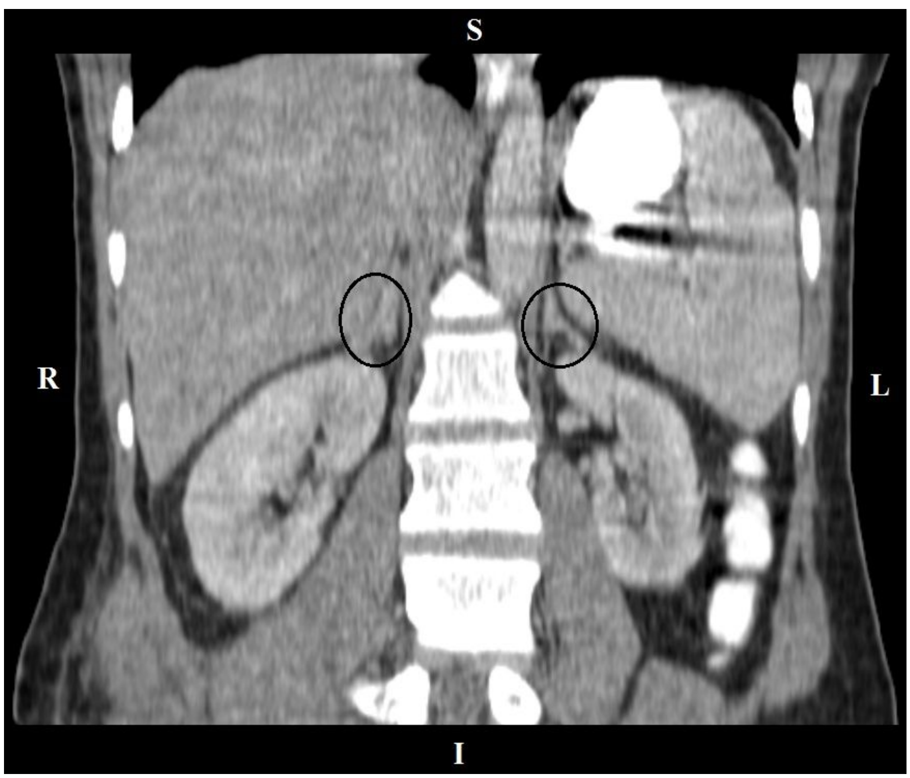

Figure 5-6: Coronal CT image for Male (36 years) shows typical location of both right and left adrenal glands.

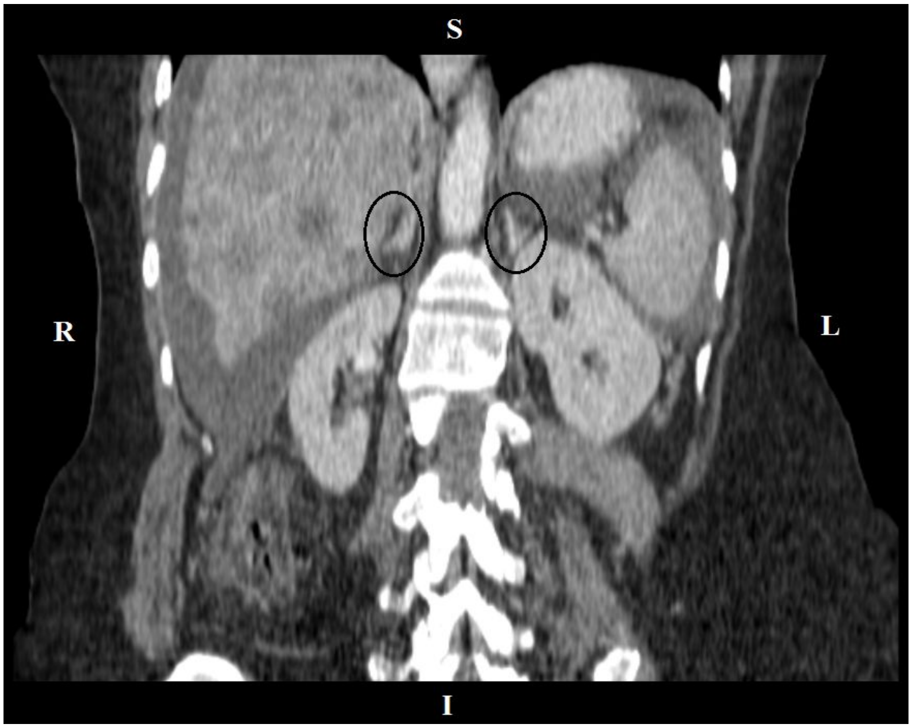

Figure 5-7: Coronal CT image for Female (42 years) shows typical location of both right and left adrenal glands.

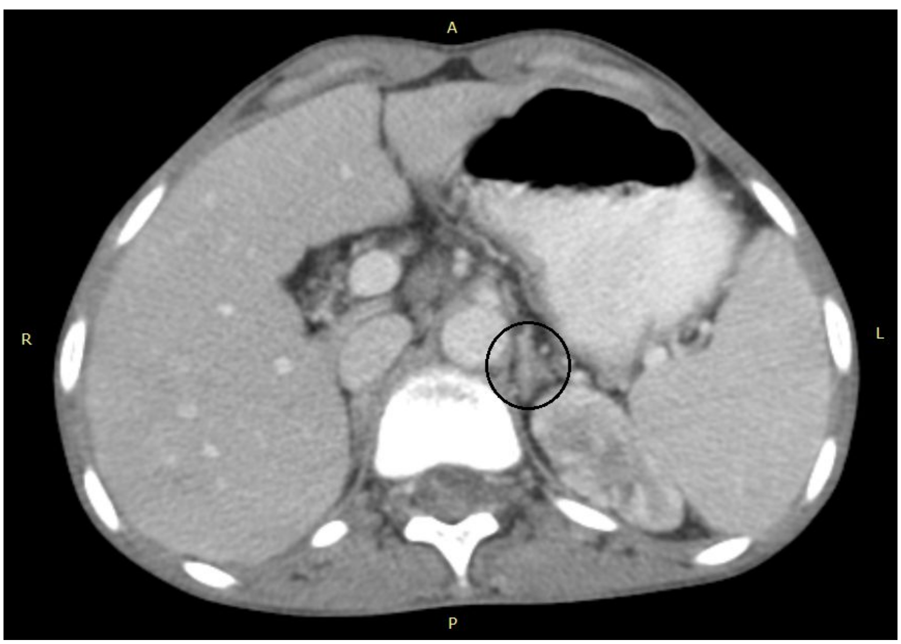

Figure 5-8: Axial CT image for Male (44 years) shows left adrenal gland (Y shape).

Figure 5-9: Axial CT image for Male (39 years) shows left adrenal gland (triangular shape).

Figure 5-10: Axial CT image for Male (42 years) shows left adrenal gland (Y shape).

Figure 5-11: Axial CT image for Female (50 years) shows right adrenal gland (V shape).

Figure 5-12: Axial CT image for Female (32 years) shows right adrenal gland (V shape).

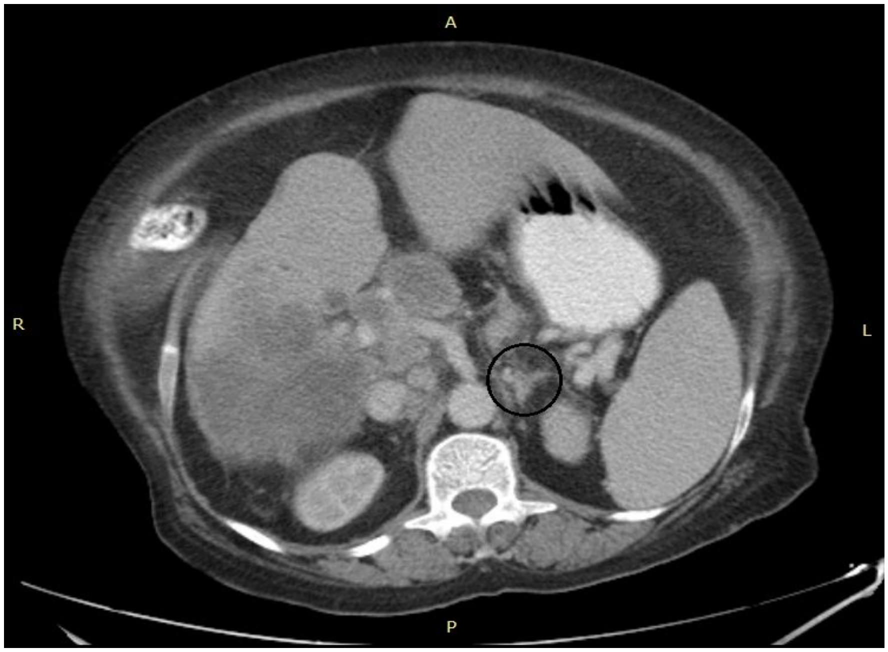

Figure 5-13: Axial CT image for Female (34 years) shows left adrenal gland (triangular shape).

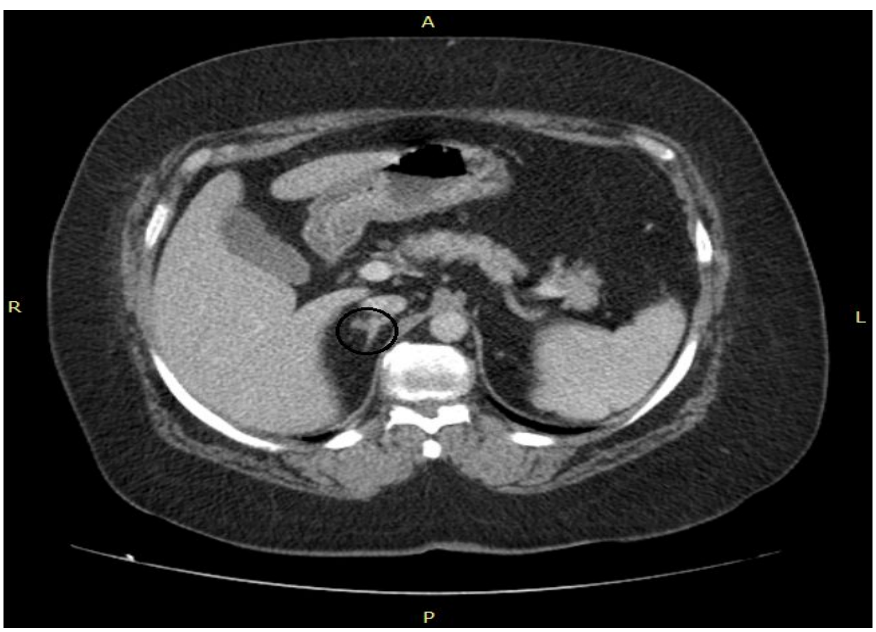

Figure 5-14: Axial CT image for Female (36 years) shows right adrenal gland (V shape).

Figure 5-15: Axial CT image for Female (33 years) shows right adrenal gland (Y shape).

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet (1)

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
1	Male	40	Rt	1	2	25	2.8	2.8	0.5	3.92	Dilated biliary tree.
			Lt	2	3	27	3.8	3.2	0.6	7.30	
2	Male	36	Rt	1	1	26	3.5	3.5	0.7	8.57	Ilio-psoas abscess and
			Lt	2	1	28	4.5	4.1	0.6	11.07	inflamed appendix.
3	Male	44	Rt	1	1	25	3.5	2.5	0.5	4.38	Renal cyst.
			Lt	2	3	27	4.0	3.0	0.6	7.20	
4	Male	33	Rt	1	3	28	4.8	3.4	0.5	8.16	
			Lt	2	1	27	4.0	3.8	0.7	10.64	
5	Male	39	Rt	1	1	26	3.5	4.1	0.5	7.18	
			Lt	2	4	25	4.5	3.2	0.5	7.20	
6	Male	42	Rt	1	2	24	4.5	2.8	0.5	6.30	Gastric tumor.
			Lt	2	3	25	4.5	2.8	0.6	7.56	
7	Male	53	Rt	1	1	22	3.5	3.4	0.5	5.95	Common bile duct stones.
			Lt	2	1	25	3.8	3.3	0.6	7.52	
8	Male	49	Rt	1	1	23	3.0	2.8	0.5	4.20	Primary liver tumor.
			Lt	2	4	24	3.5	2.6	0.5	4.55	
9	Male	61	Rt	1	1	23	2.5	2.7	0.5	3.38	Severe hepatomegaly with
			Lt	2	1	26	3.0	2.4	0.5	3.60	G.B stone.
10	Male	47	Rt	1	2	25	3.5	2.8	0.7	6.86	Hepatomegaly.
			Lt	2	3	27	3.5	3.6	0.5	6.30	

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet (2)

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
11	Male	63	Rt	1	2	22	2.5	2.5	0.5	3.13	Small G.B stone.
			Lt	2	4	25	3.5	2.6	0.5	4.55	
12	Male	56	Rt	1	1	25	2.5	3.1	0.5	3.88	Left renal cyst.
			Lt	2	2	23	3.5	2.7	0.6	5.67	
13	Male	43	Rt	1	2	25	4.0	2.0	0.6	4.80	Mild splenomegaly.
			Lt	2	3	26	4.5	3.5	0.6	9.45	
14	Male	48	Rt	1	3	24	3.5	2.8	0.5	4.90	Intestinal obstruction.
			Lt	2	4	26	3.5	2.8	0.5	4.90	
15	Male	50	Rt	1	1	24	2.5	3.9	0.5	4.88	Un remarkable study.
			Lt	2	4	26	4.5	2.4	0.5	5.40	
16	Male	64	Rt	1	2	22	2.5	2.4	0.6	3.60	Hepatic hemangioma.
			Lt	2	1	23	2.0	3.1	0.5	3.10	
17	Male	59	Rt	1	1	22	2.2	3.4	0.5	3.74	____________________
			Lt	2	3	23	3.6	2.6	0.5	4.68	
18	Male	55	Rt	1	3	23	3.2	2.8	0.7	6.27	Para neoplastic syndrome.
			Lt	2	4	24	2.4	2.6	0.5	3.12	
19	Male	49	Rt	1	1	26	2.2	3.8	0.5	4.18	____________________
			Lt	2	2	28	2.8	2.2	0.7	4.31	
20	Male	45	Rt	1	1	27	3.0	3.7	0.6	6.66	____________________
			Lt	2	2	22	3.4	2.4	0.5	4.08	

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet (3)

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
21	Male	67	Rt	1	2	22	2.8	2.6	0.7	5.10	____________________
			Lt	2	4	20	2.4	2.6	0.5	3.12	
22	Female	51	Rt	1	1	23	2.5	3.1	0.6	4.65	Hepatomegaly.
			Lt	2	4	24	4.0	2.2	0.5	4.40	
23	Female	69	Rt	1	1	23	2.0	1.9	0.5	1.90	Hepatic cysts.
			Lt	2	4	26	2.5	1.6	0.5	2.00	
24	Female	40	Rt	1	1	26	3.5	3.1	0.6	6.51	____________________
			Lt	2	4	24	4.5	2.4	0.5	5.40	
25	Female	36	Rt	1	2	26	5.0	2.6	0.6	7.80	Intestinal obstruction.
			Lt	2	4	25	4.5	2.4	0.5	5.40	
26	Female	43	Rt	1	2	24	3.8	3.2	0.6	7.30	____________________
			Lt	2	4	25	4.5	2.5	0.5	5.63	
27	Female	41	Rt	1	2	25	4.0	2.4	0.6	5.76	Liver cirrhosis.
			Lt	2	3	21	5.0	3.3	0.7	11.55	
28	Female	33	Rt	1	3	25	4.0	3.2	0.6	7.68	Ascites.
			Lt	2	4	26	4.5	3.5	0.5	7.88	
29	Female	35	Rt	1	1	26	3.5	3.6	0.6	7.56	Uterine mass.
			Lt	2	2	25	4.5	2.5	0.5	5.63	
30	Female	49	Rt	1	1	21	3.0	3.2	0.5	4.80	Left large renal cyst.
			Lt	2	2	20	3.5	2.6	0.5	4.55	

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet (4)

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
31	Female	47	Rt	1	1	25	2.8	3.6	0.5	5.04	Colonic tumor.
			Lt	2	2	23	3.5	2.4	0.6	5.04	
32	Female	42	Rt	1	1	24	4.5	4.1	0.5	9.23	Ascites and multiple liver lesions.
			Lt	2	4	24	4.0	2.6	0.5	5.20	
33	Female	51	Rt	1	1	26	2.8	3.4	0.5	4.76	Small liver cysts.
			Lt	2	4	25	3.5	2.5	0.5	4.38	
34	Female	56	Rt	1	2	23	2.8	2.5	0.5	3.50	Simple hepatic cysts.
			Lt	2	4	24	4.0	2.8	0.5	5.60	
35	Female	53	Rt	1	2	22	2.5	2.9	0.5	3.63	Right renal pelvic stone.
			Lt	2	3	23	3.5	3.0	0.6	6.30	
36	Female	50	Rt	1	2	22	2.5	2.7	0.5	3.38	Un remarkable study.
			Lt	2	3	24	3.0	2.8	0.6	5.04	
37	Female	59	Rt	1	2	22	3.5	2.6	0.5	4.55	Staghorn stone in renal pelvic.
			Lt	2	3	23	4.0	3.6	0.7	10.08	
38	Female	32	Rt	1	2	25	3.0	4.4	0.6	7.92	G.B stone.
			Lt	2	4	24	3.5	2.4	0.5	4.20	
39	Female	39	Rt	1	1	27	4.0	3.2	0.5	6.40	Sigmoid colon stone.
			Lt	2	4	28	4.5	2.5	0.5	5.63	
40	Female	41	Rt	1	1	26	2.5	3.5	0.5	4.38	Calcified uterine fibroid.
			Lt	2	2	26	3.0	2.9	0.6	5.22	

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet (5)

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
41	Female	44	Rt	1	1	25	2.5	3.0	0.6	4.50	Hepatic cyst.
			Lt	2	1	24	3.0	3.1	0.5	4.65	
42	Female	38	Rt	1	1	25	3.0	3.6	0.5	5.40	Hepatic hematoma.
			Lt	2	3	23	4.0	2.8	0.5	5.60	
43	Female	34	Rt	1	2	27	3.5	2.8	0.6	5.88	Multiple hepatic cysts.
			Lt	2	4	26	4.5	2.2	0.5	4.95	
44	Female	61	Rt	1	1	24	2.0	3.0	0.5	3.00	Large hepatic cyst.
			Lt	2	1	25	2.5	3.2	0.5	4.00	
45	Female	58	Rt	1	1	18	2.4	3.5	0.5	4.20	____________________
			Lt	2	4	16	4.2	2.2	0.5	4.62	
46	Female	40	Rt	1	2	20	2.7	2.0	0.5	2.70	Renal stone.
			Lt	2	4	21	3.6	2.3	0.5	4.14	
47	Female	30	Rt	1	2	27	2.8	2.4	0.7	4.70	____________________
			Lt	2	3	26	4.0	2.8	0.7	7.84	
48	Female	58	Rt	1	1	24	2.2	2.8	0.5	3.08	____________________
			Lt	2	4	25	2.4	2.2	0.5	2.64	
49	Female	35	Rt	1	2	28	2.0	2.6	0.5	2.60	____________________
			Lt	2	4	27	3.0	2.2	0.5	3.75	
50	Female	58	Rt	1	1	23	2.8	3.2	0.6	5.38	____________________
			Lt	2	2	24	3.4	2.2	0.5	3.74	

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.

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Characterization of the Normal Adrenal Glands with Computed Tomography in Sudanese Population

Data Collection Sheet

Pt. NO	Gender	Age	Side	Location	Shape	Texture (HU)	Length (cm)	Width (cm)	Thickness (cm)	Size (cm^3)	CT Findings
			Rt								
			Lt								
			Rt								
			Lt								
			Rt								
			Lt								
			Rt								
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			Rt								
			Lt								

Location: 1. The right lies behind the right lobe of the liver and extends medially behind the inferior vena cava. **2.** The left lies behind the pancreas, the lesser sac, and the stomach. **3.** Other.

Shape: 1. Linear. **2.** V-shaped. **3.** Y-shaped. **4.** Triangular. **5.** Other.