Sudan University of Science and Technology

College of Graduate Studies and Research

Characterization of Pancreas in Sudanese Population Using Computerized Tomography

توصيف البنكرياس للسودانيين باستخدام الأشعة المقطعية المحوسبة

A Thesis Submitted for the Requirements of the fulfillment of the Award Ph.D. Degree in Diagnostic Radiologic Technology

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2015

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بسم الله الرحمن الرحيم

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Dedication

This work is lovingly dedicated:

-To soles of my mother and grandmother

- *To my Husband and my Kids for their patience, understanding and encouragement*

- *To my father, brothers for their help and support*

- *To my friends for their valuable advice*

- To the all dearest people in my life especially my ant Bothina Elhag and Mr Ali Khalid

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constant encouragement, and for giving me a valuable times, guidance, criticism and corrections to this thesis from beginning up to end .

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ABSTRACT

This study was conducted to define the normal pancreatic size and texture for Sudanese in order to establish a local reference of values using CT scans. Computerized Tomography Scanning was performed in the Radiology Unit of the Ebn Elhaitham and Alamel Centers in Khartoum-Sudan period 2011 - 2015.

The data was collected from 252 normal subjects and were considered as group (A). 31 patients had preexisting diabetes and considered as group (B). patients age, weight, height, abdominal circumference (AC), body mass index (BMI), pancreases head CT number, Pancreas body CT number, pancreas tail CT number, pancreas head size, pancreas body size, pancreas tail size, vertebral body width vertebral body CT number, spleen CT number, for both normal and diabetic group as well as diabetic duration for the affected patients were recorded. Measurement were made and comparison took place between the normal control group and affected patients. Data were presented as mean and standard deviation (SD) for all of the variables. Comparisons between groups showed results which were significant at $P < 0.05$.

The study revealed that the Sudanese pancreas size was 28.16 ± 3.37 mm for head, 23.19 ± 3.74mm for body, 19.05 ± 3.05mm for tail and pancreas texture which was evaluated as Hounsfield was 59.02 ± 14.17for head, 57.22 ± 12.59 for pancreases body and 55.44 ± 13.12 for pancreases tail. The study showed a significant relation between the pancreas size and subject's age, height, abdomen circumference and vertebral body size, where the pancreas texture has significant relation with age ,height, abdominal circumference body width and texture vertebral and spleen texture.

Equations had been established to predict the Sudanese pancreatic size and texture. comparison between normal and diabetic samples showed that diabetes had impact on pancreas measurements, but there is no effect on pancreas texture. Long duration of DM lead to decline of pancreas size. Sudanese pancreas measurements differ from what was mentioned in other population.

ملخص الدراسة

الهدف من هذه الدراسة هو قياس أبعاد البنكرياس وكثافته للسودانيين. تعتبر الدراسة دراسة وصفية تحليلية أجريت في مستشفي ابن الهيثم والأمل الوطني في الفترة من 2011 – 2015م.

تم إجراء الدراسة على شقين تناول الأول عدد 252 عينة طبيعية مرجعية (مجموعة أ) والثاني اشتمل عدد 31 مرضي مصابين بالسكري (مجموعة ب).

خضعت كلتا المجموعتين لإجراء فحص أشعة مقطعية للبطن باستخدام جهاز أشعة مقطعية متعددة المقاطع، تم تسجيل العمر والنوع والطول والوزن ومحيط البطن ومؤشر كتلة الجسم، ثم أخذت مقاطع محورية للبطن عند مقطع البنكرياس وتم اعتبار الفقرة البطنية الأولى والطوحال نقاط مرجعية عند هذا المحور.

تم قياس أبعاد البنكرياس أمامي خلفي عند منطقة الرأس والجسم والذيل وتم أيضاً قياس كثافة نسيج البنكرياس عند كل من الأجزاء الثلاثة ومن ثم مقارنتها مع قياسات النقاط المرجعية ومتغيرات العينة. أجريت في الدراسة القياسات على المجموعتين مع وضع مدة الإصابة بالسكري في الاعتبار للمجموعة (ب).

أوضحت الدراسة النتائج الآتية: الأبعاد المرجعية للبنكرياس لعينة السودانيين (28.16 $\pm$ 3.37 ملم للرأس و 23.19 $\pm$ 3.74 ملم للجسم و 19.05 $\pm$ 3.05 ملم للذيل كقياس أمامي خلفي وكثافة النسيج الطبيعي للبنكرياس وجدت 59.02 $\pm$ 14.17 ملم للرأس و 57.22 $\pm$ 12.59 ملم للجسم و 55.44 $\pm$ 13.12 ملم للذيل.

يوجد ارتباط معنوي بين قياسات البنكرياس والعمر والطول ومحيط البطن، أظهرت النتائج أيضاً أن قياسات البنكرياس للعينة المصابة بالسكري تختلف اختلاف معنوي مع قياسات العينات الطبيعية المرجعية.

خلصت الدراسة بوضع مرجعية خاصة بالسودانيين يتم الاستناد عليها عند تشخيص مرض السكري ووضعت معادلات التنبؤ لقياسات البنكرياس للأفراد المعلومة خصائصهم الديموغرافية.

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Introduction

1.1Prelude:

In recent decades, pancreatic imaging has improved with the introduction of Ultrasonography (US), Computerized Tomography (CT), Magnetic Resonance Imaging (MRI) may provide a further enhancement in the morphological study of pancreas. [Basnet, 2011] Therefore, it has become necessary to carry out studies for the pancreas. CT scanning of the body has permitted clear invivo visualization of soft tissue anatomic structures in a cross-sectional dimension (Balthazar, 2009).

Pancreas is an oblong flattened gland located deep in the abdomen, sandwiched between the stomach and the spine. It lies partially behind the stomach. The other part is nestled in the curve of the duodenum (small intestine). This gland is an integral part of the digestive system that often goes unnoticed until problems occur, Baltimore,2011. The pancreas is located behind the stomach and is surrounded by other organs including the small intestine, liver, and spleen. It is about six inches long and is shaped like a flat pear. The wide part, called the head of the pancreas, is positioned toward the center of the abdomen; the middle section is called the neck and the body of the pancreas; the thin end is called the tail and extends to the left side. Several major blood vessels surround the pancreas, the superior mesenteric artery, the superior mesenteric vein, the portal vein and the celiac axis, supplying blood to the pancreas and other abdominal organs (Herbert, 2011).

Under a microscope, stained sections of the pancreas reveal two different types of parenchyma tissue. Lightly staining clusters of cells are called islets of Langerhans, which produce hormones that underlie the

endocrine functions of the pancreas. Darker staining cells form acini connected to ducts. Acinar cells belong to the exocrine pancreas and secrete digestive enzymes into the gut via a system of ducts (Wikipedia , 2011).Islet of Langerhans are the endocrine cells of the pancreas that produce and secrete hormones into the bloodstream. The pancreatic hormones , insulin and glucagon, work together to maintain the proper level of sugar in the blood. The sugar, glucose, is used by the body for energy. Acinar cells are the exocrine cells of the pancreas that produce and transport chemicals that will exit the body through the digestive system. The chemicals that the exocrine cells produce are called enzymes. They are secreted in the duodenum where they assist in the digestion of food (Baltimore, 2011).

The digestive action of pancreatic secretions was discovered almost 200 years later. Eberle in 1834, Purkinje and Pappenheim in 1836, and Valentin in 1844 observed the emulsification of fat, proteolytic activity, and digestion of starch, respectively, by pancreatic juice and extracts.

Bernard demonstrated the digestive action of pancreatic juice on sugar, fats, and proteins, using secretions from pancreatic fistula preparations. Kuhne introduced the term *enzyme* and isolated trypsin in 1876. The concept of enzymes led shortly to the identification of pancreatic amylase and lipase. In 1889, Chepovalnikoff, a student of Pavlov, discovered enterokinase in the duodenal mucosa, an enzyme that is essential for activation of the proteolytic enzymes. Another of Pavlov's students, Dolinsky, stimulated pancreatic secretion by instilling acid into the duodenum in 1895. This led to the discovery of secretin by Bayliss and Starling, which proved to be not an enzyme but the first hormone to be identified.The histologic structure of the pancreas was first described in 1869 by Langerhans. Shortly thereafter, Heidenhain characterized the

periodic postprandial changes that occurred in the histology of the canine pancreas. He found that as the granular regions of cells disappeared after feeding, the enzyme activity in pancreatic juice increased; he concluded that the granules contained the precursors of the digestive enzymes.

1.2 Introduction to diabetis

The mechanisms linking exocrine and endocrine pancreatic disease are the chronic inflammatory destructive processes due to genetic abnormalities facilitating and maintaining inflammation autoimmune aggression against both exocrine and endocrine cells, chronic exposure to toxic substances (e.g. alcohol or infectious agents) or an obstruction of secretory flow triggered by the daily dietary challenge of the 'western' lifestyle in conjunction with one or more of these factors (Ake, 2005).

The morphology differs regarding the race; therefore it is justifiable to carry out a study on the pancreatic morphometry in Sudanese subjects with no history of pancreatic disease or diabetes. To the best of our knowledge, no similar study was done for Sudanese population in the open literature regarding the pancreas, therefore this research was conducted to characterize the pancreas and establish a local reference of values for the pancreas measurements of the Sudanese subjects.

1.3 Problem of study

All of the anatomical organs differ according to race and Ethnic groups .The Structure may differ also due to disease and abnormalities. There is no specific characterization of the measurements and texture intensity of the pancreas in normal Sudanese. So this study is an attempt to standardize a reference values for pancreas in normal Sudanese population

1.4 Objectives of the study:

1.4.1General objective

The general objective of this study is to characterize the pancreas in Sudanese population by using CT scan to alleviate the discrepancy that arise in the pancreas measurement which attributed to body characteristic .

1.4.2 Specific Objectives:

1. To measure the pancreas head, body and tail size, in addition to density (texture) using CT Hounsfield Unit.
2. To correlate the pancreas measurements and texture with abdominal circumference, body mass index {BMI}, height, weight, age, gender in Sudanese population
3. To establish an index for Sudanese to be as standard reference value.
4. To characterize the pancreas in diabetic patients.
5. To correlate the diabetes, with Patient age, gender, body weight, abdominal circumference, BMI, Pancreases CT number, pancreases measurement of head, body, tail, duration of diabetes.
6. To compare the diabetes patients measurements findings with the standard Sudanese index.

1.5 Thesis outline:

To make the aims of the project stated above true, the thesis falls into five chapters: Chapter one, which is an introduction, deals with theoretical frame work of the study. It presents the statement of the study problems, objectives of the study, and thesis outcome. Chapter two, deals with theoretical background of pancreas (anatomy, physiology and pathology), review of the instrumentations and techniques which include pancreas assessment by clinical examination, CT imaging and literature review (previous studies). While chapter three discusses the material and method

and chapter four include presentation of the results and finally Chapter five deals with the discussion, recommendations and conclusions of the study performed as well as future work.

Chapter Two

Literature Review

Chapter Two

Literature Review

Anatomy, Physiology and Pathology

2.1 Embreolic Development of the pancreas:

A region within the endoderm committed to form the pancreas at some stage before the appearance of the first terminal differentiation products. This region presumably consists of a set of cells committed by the expression of a particular combination of transcription factors, this combination being the 'epigenetic code' for the pancreas (Slack, 1995) .The pancreas is developed in two parts, a dorsal and a ventral. The former arises as a diverticulum from the dorsal aspect of the duodenum a short distance above the hepatic diverticulum, and, growing upward and backward into the dorsal mesogastrium, forms a part of the head and uncinate process and the whole of the body and tail of the pancreas. The ventral part appears in the form of a diverticulum from the primitive bile-duct and forms the remainder of the head and uncinate process of the pancreas. The duct of the dorsal part (accessory pancreatic duct) therefore opens independently into the duodenum, while that of the ventral part (pancreatic duct) opens with the common bile-duct. About the sixth week the two parts of the pancreas meet and fuse and a communication is established between their ducts. After this has occurred the terminal part of the accessory duct, *i. e.*, the part between the duodenum and the point of meeting of the two ducts, undergoes little or no enlargement, while the pancreatic duct increases in size and forms the main duct of the gland. The opening of the accessory duct into the duodenum is sometimes obliterated, and even when it remains patent it is probable that the whole of the pancreatic secretion is conveyed through the pancreatic duct. (Slack, 1995).

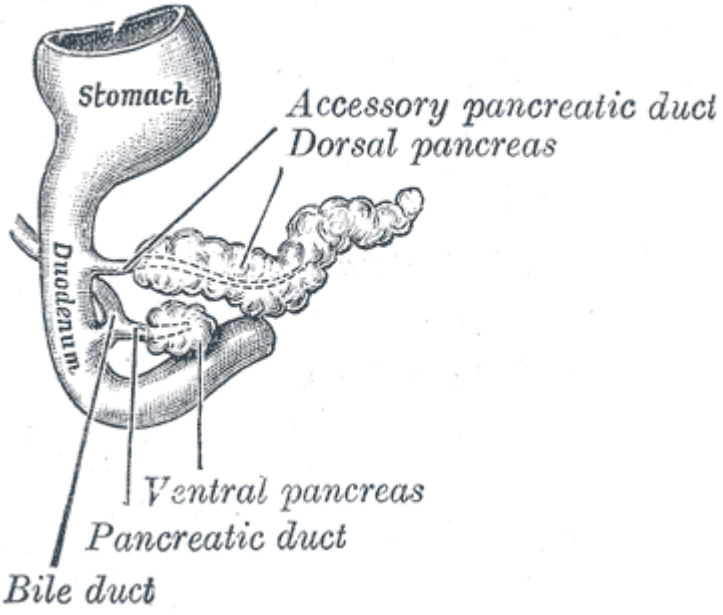

Figure 2.1 Pancreas of a human embryo of five weeks (Williams PL,1998).

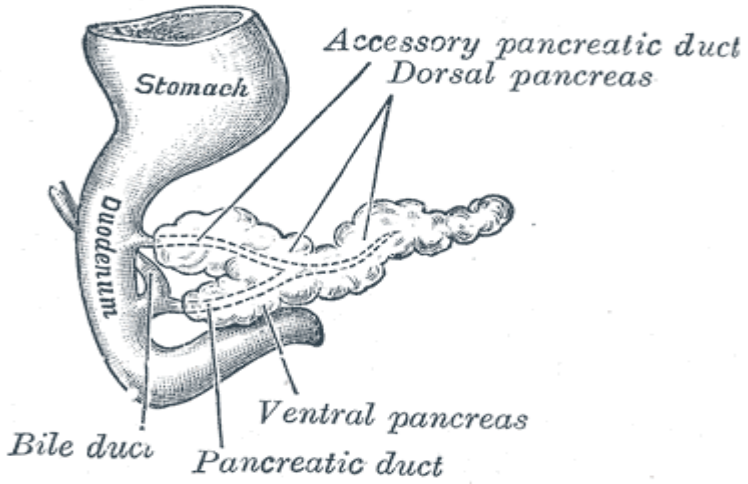

Figure 2.2 Pancreas of a human embryo at end of sixth week. (Williams PL,1998).

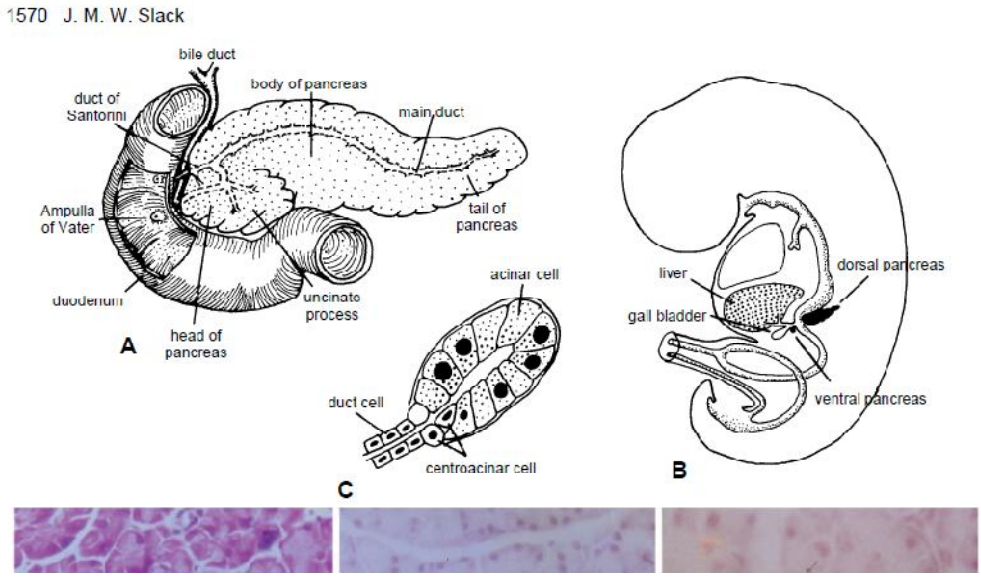

Figure 2.3. (A) Anatomy of the adult human pancreas (B) Location of the dorsal and ventral pancreatic buds in a human embryo of about 36 days (C) Hisotolgy of a pancreatic acinus (Slack, 1995).

2.2 Histology of the Pancreas

The pancreas is a compound, finely nodular gland that is grossly similar to but less compact than the salivary glands. It is surrounded by fine connective tissue but does not have a fibrous tissue capsule. The lobules are visible on gross examination and are connected by connective tissue septa that contain the blood vessels, nerves, lymphatics, and excretory ducts (constituting about 18% of this organ). The gland is a mixed exocrine (about 80%) and endocrine (about 2%) organ (Figure 2.8).

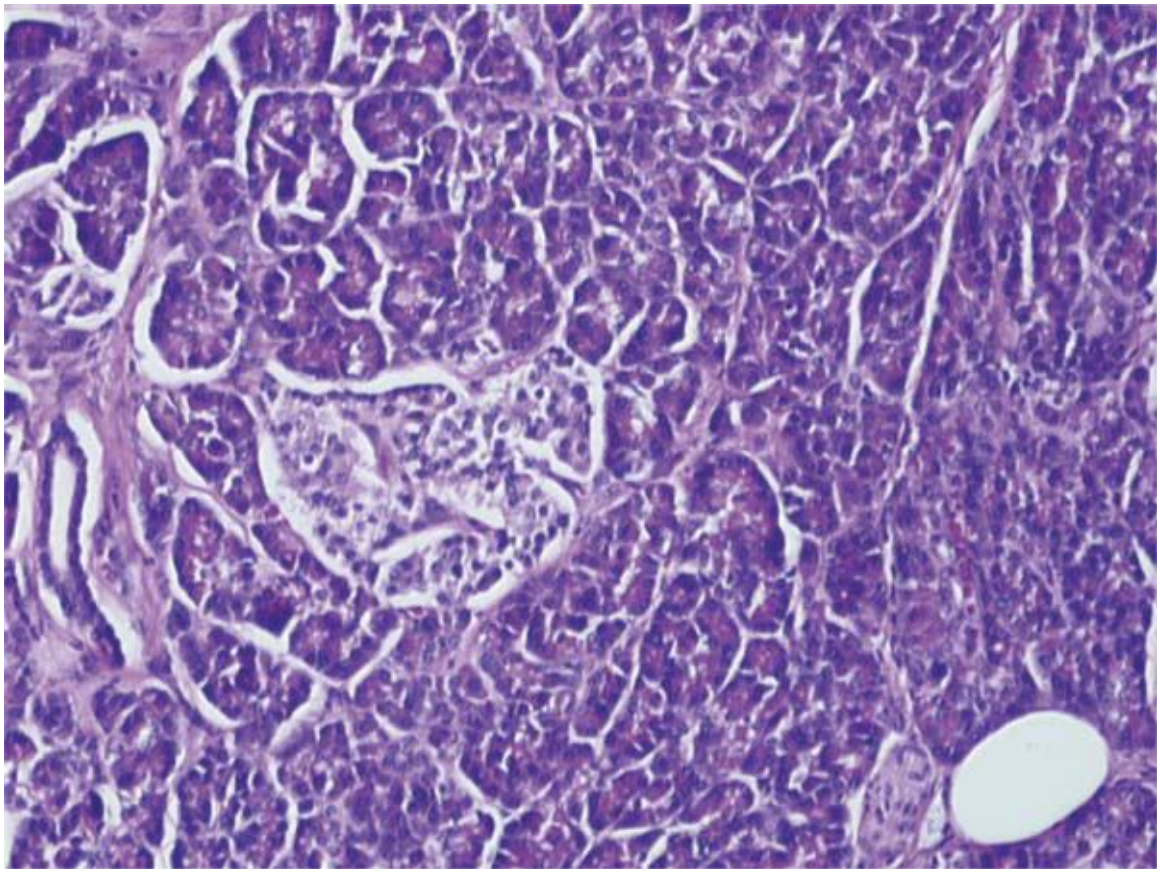

Figure 2.4 Histologic section of human pancreas obtained at autopsy shows dense-staining acinar cells and a light-staining islet of Langerhans just left of the center of the field. A small duct is visible on the left side of the illustration (9 o'clock position). Hematoxylin-eosin stain; ×140.
(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

In a normal pancreas, there are about 1 million islets, i.e. 1% of the total pancreatic tissue amount. In each islet there are about 300 cells, 75% of them beta-cells. In each beta-cell, there are about 10,000 granules,each of them containing 200,000 insulin molecules in a single crystal JOP 2005 .

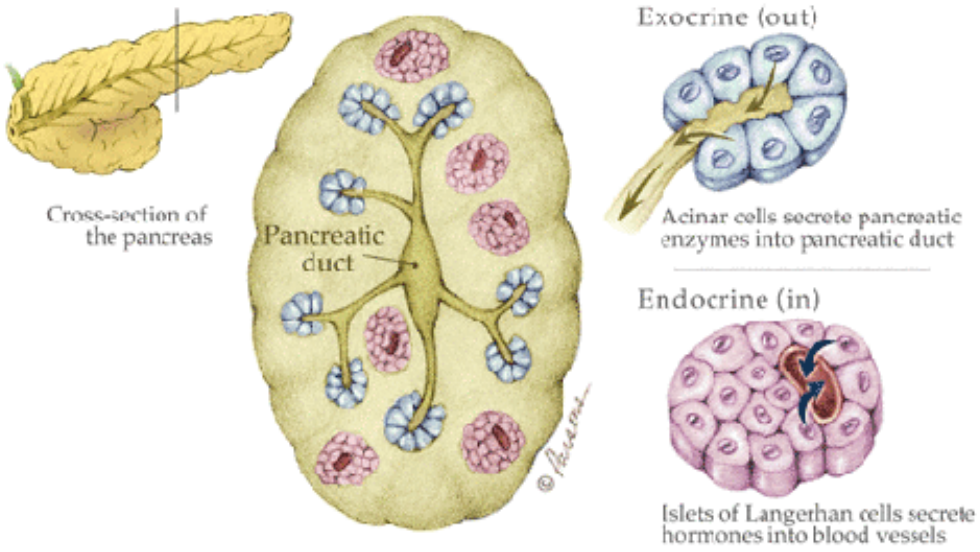

Figure 2.5 Histology of Pancreas (Baltimore, 2011).

The pancreas is divided into lobules by connective tissue septae. Lobules are composed largely of grape-like clusters of exocrine cells called acini, which secrete digestive enzymes. Exocrine secretions from acini flow successively through intercalated ducts, intralobular ducts, interlobular ducts and finally into the duodenum through the main pancreatic duct. Embedded within the pancreatic exocrine tissue are Islets of Langerhans, the endocrine component of the pancreas (Figure 2.5) . Islets contain several cell types and are richly vascularized. The islets of Langerhans comprise about 1-3 % of pancreatic weight and the concentration of islets is greater in the tail than in the head and body of pancreas (RaviRajput et al, 2001)

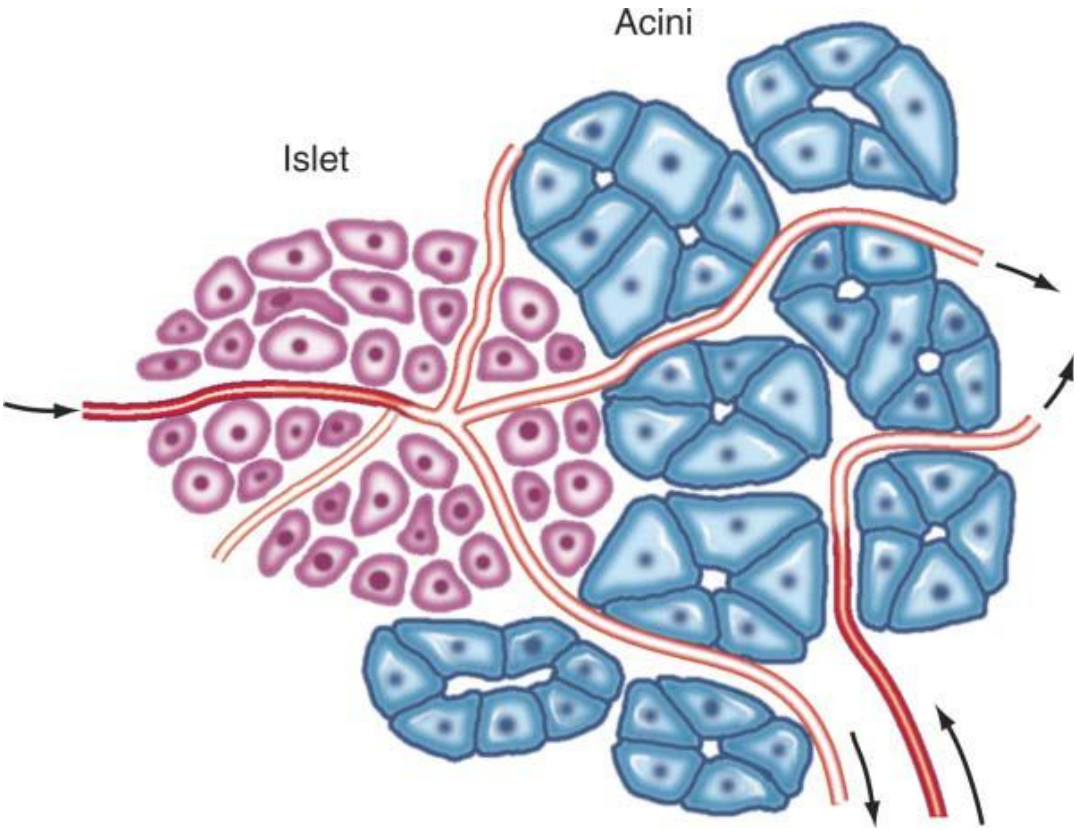

Figure 2.6 Schematic diagram of the insuloacinar portal system, illustrating the dual blood supply to the exocrine pancreas. (Goldfine ID, 1993).

Although the acinar cell secretes several different digestive enzymes in the exocrine pancreas, each cell type in the endocrine pancreas appears to secrete a single hormone. The four major types of cells found are B cells, A cells, D cells, and PP cells. B cells (beta cells), the most numerous (50% to 80%), secrete insulin. A cells or alpha cells (5% to 20%) secrete glucagon. PP (pancreatic polypeptide) cells (10% to 35%) secrete pancreatic polypeptide. D cells (5%) secrete somatostatin. Other rare cell types occur in the islet. In humans, the islets are subdivided into units, each of which exhibits a central aggregation of B cells surrounded by varying numbers of peripherally located cells that secrete the other hormones. (http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

In a normal pancreas, there are about 1 million islets, i.e. 1% of the total pancreatic tissue amount. In each islet there are about 300 cells, 75% of them beta-cells. In each beta-cell, there are about 10,000 granules,each of them containing 200,000 insulin molecules in a single crystal (JOP, 2005).

2.3 Anatomy of the Pancreas:

The pancreas is a soft, elongated, flattened gland 12 to 20 cm in length. The adult gland weighs between 70 and 110 g. The head lies behind the peritoneum of the posterior abdominal wall and has a lobular structure. The pancreas is covered with a fine connective tissue but does not have a true capsule

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

2.3.1The head of the pancreas is on the right side and lies within the curvature of the duodenum. The neck, body, and tail of the pancreas lie obliquely in the posterior abdomen, with the tail extending as far as the gastric surface of the spleen (Figure 2.7).

The second and third duodenum curvatures lie around the head of the pancreas. The anterior surface of the head of the pancreas is adjacent to the pylorus, the first part of the duodenum, and the transverse colon. The posterior surface abuts the hilus and medial border of the right kidney, the inferior vena cava and the right renal vessels, the right gonadal vein, and the right crus of the diaphragm.

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

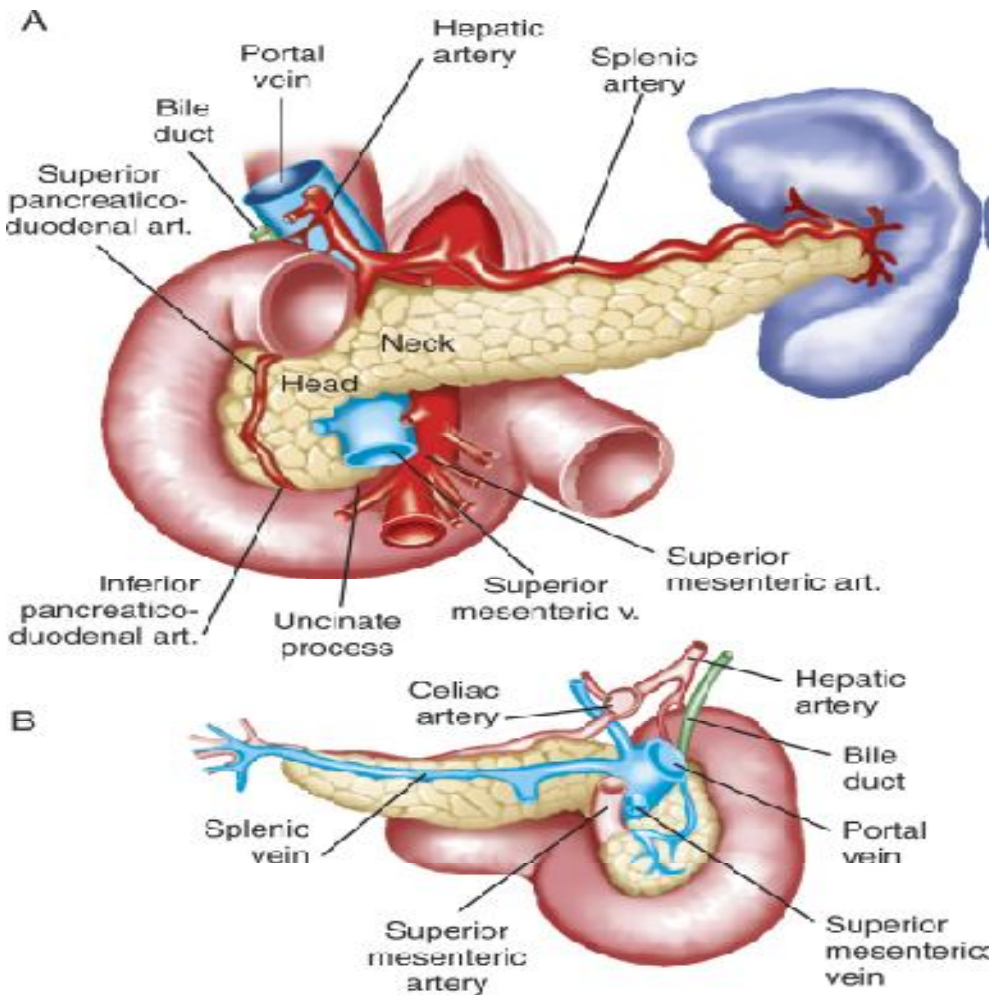

Figure 2.7 Diagrammatic representations of the pancreas. A, Anterior view; B,posteriorview.(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

2.3.2 The uncinate process is a prolongation of pancreatic tissue of variable size and shape. It projects off the lower part of the head of the pancreas, extending upward and to the left. The uncinate process lies anterior to the aorta and inferior vena cava and is covered superiorly by the superior mesenteric vessels that emerge below the neck of the pancreas. There is much variation in the uncinate process, which may even be absent altogether (figure 2.8).

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

2.3.3The neck of the pancreas is a constricted part of the gland extending from the head of the pancreas toward the left, joining the head with the body of the pancreas. It is 1.5 to 2.0 cm long and 3.0 to 4.0 cm wide. Posterior to the neck of the pancreas lies the confluence of the portal vein with the superior mesenteric and splenic veins. Anteriorly it is covered in part by the pylorus and peritoneum of the lesser sac. The neck extends to the right as far as the anterosuperior pancreaticoduodenal artery from the gastroduodenal artery.

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html)

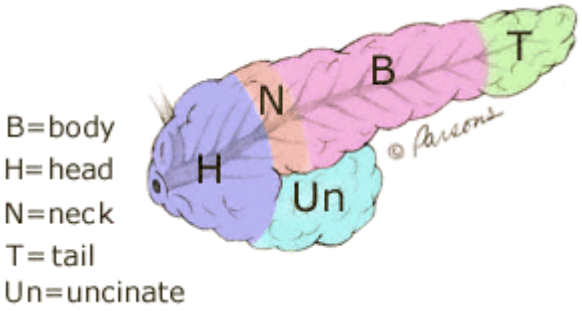

Figure 2.8 Diagrammatic representations of the pancreas. Head, Body ,Tail and uncinate.

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html)

2.3.4The body of the pancreas runs toward the left side, anterior to the aorta. It is retroperitoneal and held against the aorta by the peritoneum of the lesser sac. The anterior surface of the body is covered by peritoneum of the omental bursa that separates the stomach from the pancreas. The antrum and body of the stomach and the transverse mesocolon contact the body anteriorly. Posterior to the body of the pancreas are the aorta, the origin of the superior mesenteric artery, the left crus of the diaphragm, the left kidney, the left adrenal gland, and the splenic vein. The midline part of the body

overlies the lumbar spine, which makes this area of the pancreas most vulnerable to abdominal trauma. The body passes laterally and merges with the tail.
(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

2.3.5 Tail of the pancreas without a discernible junction point. The tail is relatively mobile, its tip usually reaching the hilus of the spleen. With the splenic artery and vein, the tail is contained between the two layers of the splenorenal ligament. The splenocolic ligament attaches the splenic flexure of the colon to the spleen and brings it near the tail of the pancreas.
(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

The transpyloric plane defines the level of the neck of the pancreas which overlies the vertebral column. From this landmark, the head can be imagined passing downward and to the right, the body and tail passing upwards and to the left. (Harold Ellis, 2006).

The relationship of the pancreas to important structures in the posterior abdomen is seen in (Figure 2.9).

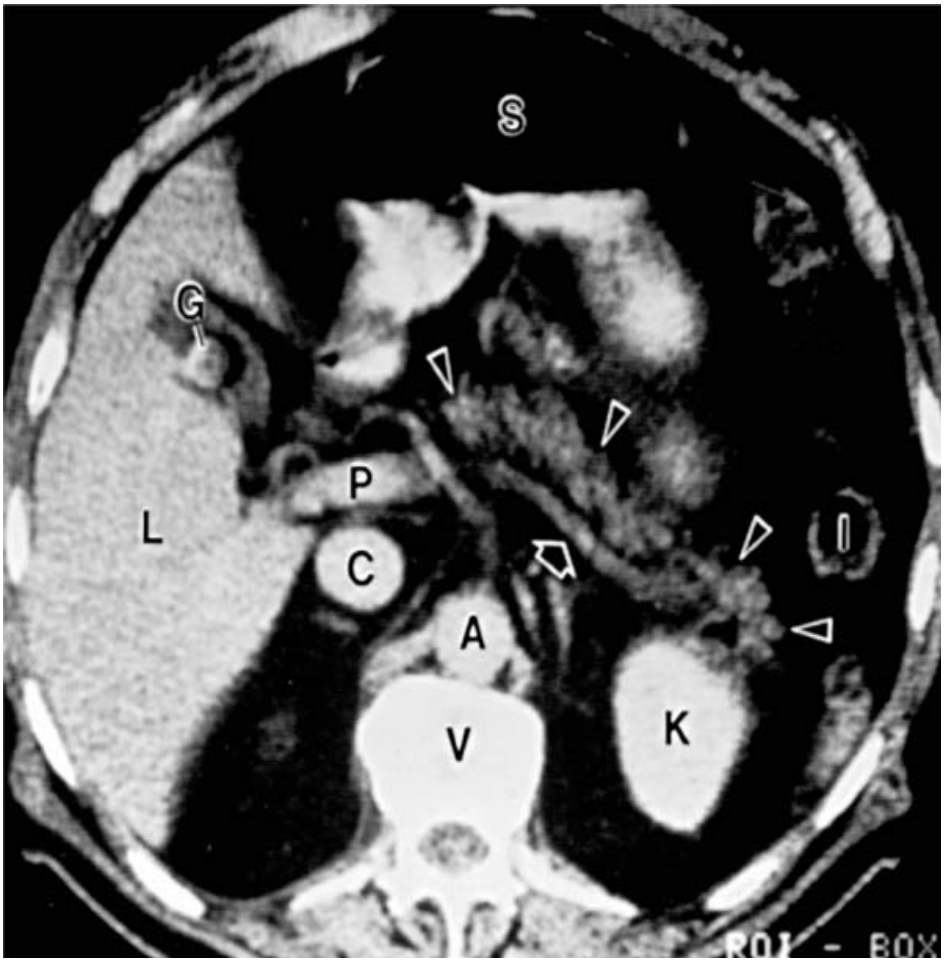

Figure 2.9 Normal anatomic relation of the pancreas with other intra-abdominal structures as shown by computed tomography. The borders of the pancreas are indicated by arrowheads. The splenic vein is indicated by an arrow. A, aorta; C, vena cava; G, incidental gallstone; I, small intestine; K, left kidney; L, liver; P, portal vein; S, stomach; V, vertebra.
(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

The distal end of the common bile duct, the duodenum, and the head of the pancreas form a unit .The common bile duct is located to the right of the gastroduodenal artery in the posterior wall of the duodenum. The bile duct passes through the substance of the pancreatic head, usually to join with

the main pancreatic duct for some distance to reach the duodenal papilla (Figure 2.10).

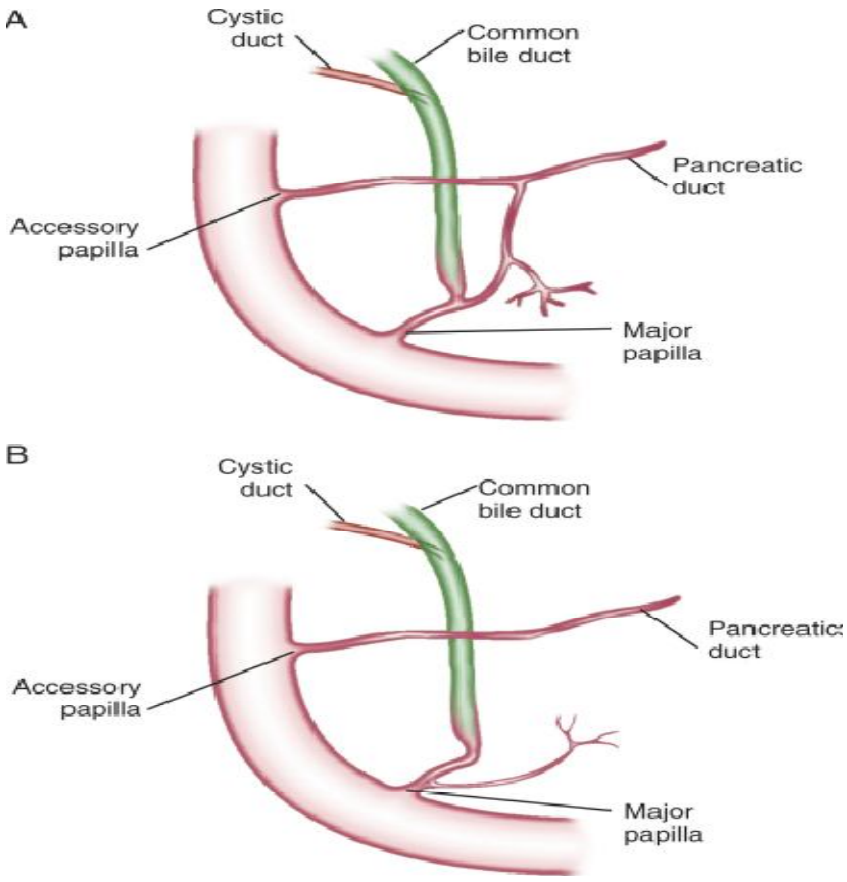

Figure 2.10 Anatomic arrangement of the pancreatic duct system. A, The most common arrangement. Most of the pancreatic secretion empties into the duodenum along with bile through the major papilla. The proximal portion of the embryonic dorsal pancreatic duct remains patent in about 70% of adults and empties through the accessory papilla. B, Pancreas divisum. The embryonic dorsal and ventral ducts fail to fuse. Most of the pancreatic secretion empties through the accessory papilla. Only pancreatic secretions from the uncinate process and part of the head of the pancreas (which are derived from the embryonic ventral pancreas) drain through the duodenal papilla.

(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

2.3.6 Ductal Structures

The main pancreatic duct (of Wirsung) begins near the tail of the pancreas. It is formed from anastomosing ductules draining the lobules of the gland. It courses left to right and is enlarged by additional ducts. Through the tail and body, the duct lies midway between the superior and inferior margins and slightly posterior. The main duct turns caudal and posterior on reaching the head of the pancreas. At the level of the major papilla, the duct turns horizontally to join usually with the common bile duct (figure. 2.10.A). This short common segment is the ampulla of the bile duct, which terminates in the duodenal papilla. The relationship of the common bile duct and the duct of Wirsung at the papilla is complex. The ducts may open separately at the ampulla and have an interposed septum or may have a common channel. A common channel for bile and pancreatic secretion is ordinarily formed by the absence of a septum between the biliary and pancreatic ducts as they approach the ampulla of Vater. In adults studied by endoscopic retrograde cholangiopancreatography (ERCP), the length of the common channel averages 4.5 mm, with a range of 1 to 12 mm. In various series, more than two thirds of patients had some degree of a common channel. In a large autopsy series, 74% of patients had a common channel, 19% had separate openings, and 7% had an interposed septum. (http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

The accessory pancreatic duct of Santorini is frequently present and usually communicates with the main duct (Fig. 2.10.B). The accessory duct lies anterior to the bile duct and usually drains into the minor papilla, which lies proximal to the ampulla of Vater in the second duodenum. The accessory duct is patent in 70% of autopsy specimens. In about 10% of individuals there is no connection between the accessory duct and the main

duct. A number of variations in the two pancreatic ducts may be encountered.

The greatest diameter of the main pancreatic duct is in the head of the pancreas, and the duct gradually tapers, progressing to the tail of the pancreas. The main duct ranges from 3.1 to 4.8 mm in the head of the pancreas and tapers to 0.9 to 2.4 mm in the tail. Specific normal limits of pancreatic duct diameter in the head (4 to 5 mm), body (3 to 4 mm), and tail (2 to 3 mm) are generally accepted. However, studies have shown an increase in pancreatic duct size with age and pancreatic disease. (http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html)

2.3.7 Blood circulation Blood supply

The pancreas receives blood from branches of both the celiac artery and superior mesenteric artery. The splenic artery runs along the top margin of the pancreas, and supplies the neck, body and tail of the pancreas through its pancreatic branches, the largest of which is called the greater pancreatic artery. The superior pancreatico-duodenal artery and inferior pancreatico-duodenal artery run along the anterior and posterior surfaces of the head of the pancreas at its border with the duodenum. These supply the head of the pancreas (Drake et al, 2005).

The body and neck of the pancreas drain into splenic vein; the head drains into the superior mesenteric and portal veins (Drake et al, 2005).

2.3.8 The lymphatic drainage of Pancreas

The lymphatics drain into nodes which lie along its upper border, in the groove between its head and the duodenum, and along the root of the superior mesenteric vessels (Harold Ellis, 2006).

2.4 Physiology of pancreas :

The pancreas can be thought of as having different functional components, the endocrine and exocrine parts (Baltimore, 2011). The pancreas is divided into lobules by connective tissue septae. Lobules are composed largely of grape-like clusters of exocrine cells called acini, which secrete digestive enzymes. Exocrine secretions from acini flow successively through intercalated ducts, intralobular ducts, interlobular ducts and finally into the duodenum through the main pancreatic duct. Embedded within the pancreatic exocrine tissue are Islets of Langerhans, the endocrine component of the pancreas. Islets contain several cell types and are richly vascularized. The islets of Langerhans comprise about 1-3 % of pancreatic weight and the concentration of islets is greater in the tail than in the head and body of pancreas (RaviRajput et al, 2001).

The pancreas is controlled by both the autonomic nervous system and the endocrine system. The ANS has 2 divisions: the sympathetic and the parasympathetic. Nerves of the sympathetic division become active during stressful situations, emergencies, and exercise. Sympathetic neurons stimulate the alpha cells of the pancreas to release the hormone glucagon into the bloodstream. Glucagon stimulates the liver to begin the breakdown of the energy storage molecule glycogen into smaller glucose molecules. Glucose is then released into the bloodstream for the organs, especially the heart and skeletal muscles, to use as energy. The sympathetic nerves also inhibit the function of beta cells and acini to reduce or prevent the secretion of insulin and pancreatic juice. The inhibition of these functions provides more energy for other parts of the body that are active in dealing with the stressful situation. (American Diabetes Association, 2014).

Nerves of the parasympathetic division of the ANS become active during restful times and during the digestion of a meal. Parasympathetic nerves stimulate the release of insulin and pancreatic juice by the pancreas. Pancreatic juice helps with the digestion of food while insulin stores the glucose released from the digested food in the body's cells. The endocrine system uses 2 hormones to regulate the digestive function of the pancreas: secretin and cholecystokinin (American Diabetes Association, 2014).

Cells in the lining of the duodenum produce secretin in response to acidic chyme emerging from the stomach. Secretin stimulates the pancreas to produce and secrete pancreatic juice containing a high concentration of bicarbonate ions. Bicarbonate reacts with and neutralizes hydrochloric acid present in chyme to return the chyme to a neutral pH of around 7. (American Diabetes Association, 2014).

CCK is a hormone produced by cells in the lining of the duodenum in response to the presence of proteins and fats in chyme. CCK travels through the bloodstream and binds to receptor cells in the acini of the pancreas. CCK stimulates these cells to produce and secrete pancreatic juice that has a high concentration of digestive enzymes. The high levels of enzymes in pancreatic juice help to digest large protein and lipid molecules that are more difficult to break down. (American Diabetes Association, 2014).

2.5 Pathology of the pancreas

2.5.1. Congenital Disorders

1. Ectopic pancreatic tissue -usually is asimptomatic -most frequently sites: stomach and duodenum, jejunum, Meckel's diverticulum (Webmed, 2011).

2.5.1.1 Annular pancreas -the pancreatic head encircles the duodenum with attendant risk of obstruction -cause duodenal stenosis in infants with vomiting and failure to thrive (Webmed, 2011).

2.5.1.2 Pancreas divisum -persistence of the two separate pancreatic ducts -predisposes to recurrent pancreatistis (Webmed, 2011).

2.5.1.3 Cystic fibrosis -autosomal recessive systemic disorder affects all exocrine gland -a biochemical disorder of exocrine secretions causes the viscid secretions to be impacted in the exocrine ducts.-80% have a pancreatic exocrine insufficiency manifested by diabetes mellitus due to pancreatic endocrine insufficiency may also be found (Webmed, 2011).

2.5.1.4 Pancreatic cancer: The pancreas has many different types of cells, each of which can give rise to a different type of tumor. The most common type arises from the cells that line the pancreatic duct. Because there are usually few or no early symptoms, pancreatic cancer is often advanced by the time it's discovered (Webmed, 2011).

2.5.1.5 Pancreatitis: The pancreas becomes inflamed and damaged by its own digestive chemicals. Swelling and death of tissue of the pancreas can result. Although alcohol or gallstones can contribute, the cause of most pancreatitis is unknown (Webmed, 2011).

2.5.1.6 Pancreatic pseudocyst: After a bout of pancreatitis, a fluid-filled cavity called a pseudocyst can form. Pseudocysts may resolve spontaneously, or they may need surgical drainage (Webmed, 2011).

2.5.1.7 Islet cell tumor: The hormone-producing cells of the pancreas multiply abnormally, creating a benign or cancerous tumor. These tumors produce excess amounts of hormones and then release them into the blood. Gastrinomas, glucagonomas, and insulinomas are examples of islet cell tumors (Webmed, 2011).

2.5.2 Overview: Types of Diabetes Mellitus

Diabetes mellitus (DM) is a common disease in which the blood sugar (glucose) is abnormally elevated. Normally, the body obtains glucose from

food. The produces insulin, which enables glucose to enter cells and serve as fuel for the body. In patients with diabetes, glucose accumulates in the blood instead of being properly transported into cells. Excess blood sugar is a serious problem that may damage the blood vessels, and other organs (Carla, 2011).

About 5-10% of patients with diabetes are diagnosed with type 1 diabetes mellitus , an autoimmune disorder in which the mistakenly attacks the insulin-producing beta cells in the pancreas, causing the organ to no longer produce insulin. Type 1 DM most commonly occurs in children or young adults, and the incidence of new cases is increasing (Carla, 2011).

The patients having type 1 diabetes, must be treated with insulin given in the injection form, as injections (Carla, 2011).

Type-2-Diabetes occurs mostly due to a so-called insulin resistance, which means your body's cells with a reduced sensitivity to insulin, so that the insulin cannot play the role of lowering blood sugar. A disturbed insulin secretion and previous overproduction of insulin causing an existing exhaustion of the insulin-producing cells are both responsible for type-2-Diabetes. This diabetes is the most common form, that makes up approx. 93.5 percent ratio and mostly occurs in adults. Obviously, type 2 diabetes frequently involves obese population and families, which indicate the risk factors related to familial predisposition and dietary habits (Carla, 2011).

A person who eats a lot of carbohydrate food, will be able to "wear out" beta cells in the pancreas after a while (after a time). Amyloid protein produced along with the insulin namely amylin. Amylin can build up (accumulate) and form fibrils, so that beta cells may enter into apoptosis (programmed cell death). This may be a reason why beta cells of people with type 2 diabetes are unable to produce enough insulin, and glucose levels will

thus not be lowered sufficiently. The insulin produced in people with type 2 diabetes, also has less effect on cells than normal. We say that they have insulin resistance (Carla, 2011).

Gestational diabetes mellitus (GDM) occurs during pregnancy. This form of diabetes usually resolves after delivery, but patients with GDM have an increased risk of developing type 2 DM later in life (Carla, 2011).

2.5.2.1 Causes of DM and Risk Factors

Type 1 DM is an autoimmune disorder and the exact cause is unknown. Causes may include genetic factors, environmental factors, and viruses (Carla, 2011)..

For type 2 DM, the major risk factors include a family history of type 2 DM, increased age, obesity, and a sedentary lifestyle. Type 2 DM can develop in people who are not obese, but obesity is a major risk factor because excess body fat causes insulin resistance (Carla, 2011).

Gestational diabetes mellitus is caused by certain hormones associated with pregnancy that interfere with insulin's function. GDM occurs more frequently in patients who are overweight, are older than 25, have close relatives with diabetes, or have given birth to a baby weighing more than 9 pounds (Carla, 2011).

Steroid medication may cause diabetes or exacerbate existing disease. DM is also caused by excess hormone production, genetic disorders that impair insulin activity, and pancreatic diseases (Carla, 2011).

2.5.2.2 Symptoms and Complications

People with type 1 DM usually experience a sudden onset of symptoms including frequent urination ,extreme thirst ,weight loss, abnormal hunger, fatigue and blurred vision (Carla, 2011).

The severity of symptoms depends on the blood sugar level. Individuals with type 2 DM usually have a much more gradual onset of symptoms, and many people with type 2 DM are asymptomatic for years.
Diabetic ketoacidosis (DKA) is a life-threatening condition associated with increased fat metabolism and production of harmful acids (ketones). Patients diagnosed with DKA develop very high blood sugar levels, abdominal pain, fruity-smelling breath, dehydration, severe weakness, lethargy, and coma.
.Hyperglycemic hyperosmolar nonketotic syndrome is characterized by extremely high blood sugar levels, dehydration, fever, confusion, and coma.causes the narrowing of arteries throughout the body. This problem increases the risk for coronary heart disease, , cerebrovascular disease, stroke, and impaired circulation to the legs (peripheral artery disease) (Carla, 2011).

Damage to nerves (neuropathy) in the arms and legs causes decreased sensation, numbness, and tingling. Neuropathy and poor blood circulation in the feet can cause non-healing wounds and infections that may necessitate lower extremity amputations. Damage to ultimately impairs kidney function (nephropathy). paired blood flow in the retina (diabetic retinopathy) can lead to blindness (Carla, 2011).

2.5.2.3 Diagnosis of Diabetes

Patients with type 1 DM often develop pronounced symptoms of diabetes, so the disease is usually readily diagnosed. Conversely, people with type 2 DM may experience no symptoms. Screening tests are important for high risk groups, such as pregnant women, people with a family history of diabetes, and people older than 45.Prediabetes is a condition of mildly elevated blood glucose levels found in people at risk for developing type 2 DM. Prediabetes is often diagnosed upon routine screening of otherwise

asymptomatic individuals. With early lifestyle changes, prediabetes is reversible. (Carla, 2011).

Autoimmunity in diabetes mellitus ,even though it is still not known today if diabetes type1 is due to:

1. autoimmune beta-cell destruction;
2. chronic infection of beta-cells;
3. other causes (microbial or sterile) leading
4. to the preferential death of the beta-cells.

type 1 diabetes affects only beta-cells and not alpha-,delta-, and pancreatic polypeptide (PP)-cells or exocrine cells. The focus of beta-cell autoimmunity on a few phylogenetically conserved antigens fits, however, with the role of phylogenetically conserved receptors of innate immunity. A hypothesis is that heat shock proteins direct the innate immune system towards the beta-cells. This may depend on the fact that heat shock protein contains homologous regions for the key antigens showed experimental indications that the innate immune system may be crucial for guiding Tcell immune reactivity towards a limited number of autoantigens and activation of autoimmune T-cells (Ake Andren-Sandberg, 2005).

Prevalence in both insulin-dependent or insulin-independent patients. Exocrine pancreatic failure has often been perceived as a complication of diabetes. In contrast, Exocrine pancreatic insufficiency is frequently associated with diabetes, with high recent clinical observations lead to the notion that nonendocrine pancreatic disease is a critical factor for development rather than a sequel to diabetes. The incidence of diabetes caused by exocrine pancreatic disease appears to be underestimated and may comp:val observations lpl:spagens (Ake Andren-Sandberg, 2005).

2.6 Pancreas Investigations:

2.6.1 Physical examination: By pressing on the center of the belly, a doctor might check for a mass in the pancreas. He or she can also look for other signs of pancreas conditions (Webmed, 2011).

2.6.2 A CT scan of the pancreas: may be performed to assess the pancreas for tumors and other lesions, injuries, bleeding, infections, abscesses, unexplained abdominal pain, obstructions, or other conditions, particularly when another type of examination, such as X-rays or physical examination, is not conclusive. CT scans of the pancreas may be used to distinguish between disorders of the pancreas and disorders of the retroperitoneum (the back portion of the abdomen behind the peritoneal membrane (Yale, 2012).

2.6.3 Magnetic resonance imaging (MRI): Magnetic waves create highly detailed images of the abdomen. Magnetic resonance Cholangio - pancreatography (MRCP) is an MRI that focuses on the pancreas, liver, and bile system (Webmed, 2011).

2.6.4 Endoscopic retrograde cholangiopancreatography (ERCP): Using a camera on a flexible tube advanced from the mouth to the intestine, a doctor can access the area of the pancreas head. Tiny surgical tools can be used to diagnose and treat some pancreas conditions (Webmed, 2011).

2.6.5 Pancreas biopsy: Either using a needle through the skin or a surgical procedure, a small piece of pancreas tissue is removed to look for cancer or other conditions (Webmed, 2011).

2.6.6 Ultrasound: A probe is placed on the belly, and harmless sound waves create images by reflecting off the pancreas and other organs (Webmed, 2011).

2.6.7 Blood tests: Amylase and lipase blood tests showing elevated levels of these pancreatic enzymes can suggest pancreatitis (Webmed, 2011).

2.6.8 Sweat chloride test: A painless electric current stimulates the skin to sweat, and the chloride in perspiration is measured. People with cystic fibrosis often have high sweat chloride levels (Webmed, 2011).

2.6.9 Genetic testing: Many different mutations of a single gene can cause cystic fibrosis. Genetic testing can help identify if an adult is an unaffected carrier or if a child will develop cystic fibrosis (Webmed, 2011).

2.6.10 Tests for Diabetes

- Fasting blood glucose is measured after an 8 hour fast.Normal: less than 100 mg/dlPrediabetes: 100-125 mg/dlDiabetes: 126 mg/dl or higher
- Oral glucose tolerance test (OGTT) is performed after consumption of a high-glucose solution.Normal: less than 140 mg/dlPrediabetes: 140-199 mg/dlDiabetes: 200 mg/dl or higher
- Random blood glucose of 200 mg/dl or higher indicates diabetes.
- Glycated hemoglobin (A1C) is an indicator of a person's average blood sugar for the past 2 or 3 months. The test measures the percent of hemoglobin adherent to glucose molecules .Normal: less that 5.7%Prediabetes: 5.7-6.4%Diabetes: 6.5% or higher (Calara J,2011)

2.7 Computerized Tomography Scanning(Over View)

Is a technology that uses computer-processed x-rays to produce tomographic images (virtual 'slices') of specific areas of the scanned object, allowing the user to see inside without cutting. Digital geometry processing is used to generate a three-dimensional image of the inside of an object from a large series of two-dimensional radiographic images taken around a single axis of rotation.(Herman2009) .It combines a series of X-ray views taken from many different angles and computer processing to create cross-sectional images of the bones and soft tissues inside your body (Mayo, 2012) .CT scan images

can provide much more information than do plain X-rays. A CT scan has many uses, but is particularly well suited to quickly examine people who may have internal injuries from car accidents or other types of trauma. A CT scan can be used to visualize nearly all parts of the body. It has many uses, but is particularly well suited to quickly examine people who may have internal injuries from car accidents or other types of trauma (Mayo, 2012).

A CT scan can be used to visualize nearly all parts of the body and itrecommend a to help in diagnose muscle and bone disorders, such as bone tumors and fractures ,Pinpoint the location of a tumor , infection or blood clot ,guide procedures such as surgery, biopsy and radiation therapy ,detect and monitor diseases and conditions such as cancer, heart disease, lung nodules and liver masses and detect internal injuries and internal bleeding (Mayo, 2012)

2.7.1.1 The basic principles of CT

Fundamentally a CT scanner makes many measurements of attenuation through the plane of a finite thickness cross section of the body. The system uses these data to reconstruct a digital image of the cross section in which each pixel in the image represents a measurement of the mean attenuation of a box-like element (voxel) extending through the thickness of the section. An attenuation measurement quantifies the fraction of radiation removed in passing through agiven amount of a specific material of thickness. A CT signal results from tissue discrimination based on the variations in attenuation between “voxels,” which depends on differences in voxel density and atomic number of elements present and is influenced by the detected mean photon energy.
(http://science.howstuffworks.com/cat-scan.htm).

2.7.1.2 The pitch

The concept of “pitch” was introduction with the arrival of helical or spiral CT scanners. Pitch is defined as the ratio of table travel per gantry rotation to the x-ray beam width .Pitch = I/W where I is table feed per gantry rotation (mm/rotation) and W is x-ray beam width (mm).
(http://science.howstuffworks.com/cat-scan.htm).

2.7.1.3 Field of view”(FOV) in CT

The FOV in CT is the area of scan region that is included in the image reconstruction. There are two types of FOV: scan FOV (SFOV) and display FOV (DFOV). SFOV is the region within the gantry opening, the anatomy that is included in the reconstruction. SFOV is less than the physical opening of the CT gantry, which is the reason why part of the anatomy is cut off in scanning larger patients. On the other hand, DFOV is area of reconstructed image that can be displayed. Smaller DFOV results in larger image size. The SFOV influences the physical dimensions of image pixel. Prokop M 2003
One common feature of the detector array designs of 16-slice MDCT compared with 4-slice MDCT is that all major manufacturers have migrated toward the “hybrid” detector design with thin detectors (16) in the center and thick detectors (4) at either sides. The scan acquisition modes are obtained as either 16 thin slices or 16 thick slices per gantry rotation.
(http://science.howstuffworks.com/cat-scan.htm).

2.7.1.4 Hounsfield units – To honour Hounsfield for his work the mean X-ray attenuation within one pixel (also known as CT number) is expressed in Hounsfield units (HU). Measured values of attenuation are transformed into CT numbers using the international Hounsfield scale:CT number = 1000□(μ – μwater)/μwater In this expression μ is the effective linear attenuation

coefficient for the X-ray beam. This scale is so defined that air and water respectively have the following CT numbers: –1000 and 0 HU. (http://science.howstuffworks.com/cat-scan.htm).

Refinements in detector technology allow new CT scanners to obtain multiple slices in a single rotation. These scanners, called multislice CT or multidetector CT, allow thinner slices to be obtained in a shorter period of time, resulting in more detail and additional view capabilities. (Myo clinic 2014)

Modern CT scanners are so fast that they can scan through large sections of the body in just a few seconds, and even faster in small children. Such speed is beneficial for all patients but especially children, the elderly and critically ill, all of whom may have difficulty in remaining still, even for the brief time necessary to obtain images.(Myo clinic 2014)

Figure (2.11) CT Scan unit (Yale, 2012).

2.7.2 CT Technique For abdomen

Current multidetector CT technology (Light-Speed QX/i; General Electric Medical Systems, Milwaukee, WI) captures four helical scans of data during a single 0.8-sec gantry rotation. After an initial digital scout radiograph of the abdomen has been obtained, a series of unenhanced scans is obtained using a 10- to 12-sec breath-held acquisition, 10-mm collimation ,and a pitch of 6 (high-speed mode). The unenhanced scans are used to define the target volume that will be scanned during an IV injection of contrast material. The patient must be instructed to attempt to achieve a similar level of deep inspiration during all scan acquisitions to ensure that the target volume is not missed. For a patient referred primarily for pancreatic studies, the target volume is from the celiac axis to the transverse duodenum. For a patient referred for biliary scans, the target volume is from approximately 2 cm above the porta hepatis to the level of the transverse duodenum. Immediately before scanning, the patient is asked to ingest 941.2 mL of water as a nonopaque intraluminal contrast agent. After insertion of a 20-gauge catheter into an antecubital vein, 150 mL of iohexol 300 mg I/mL (Omnipaque; Nycomed, Princeton, NJ) iodinated contrast material is injected at a rate of 4 mL/sec with a power injector.Forty seconds after initiation of the injection, 1.25-mm nominal thickness sections are obtained during a 15- to 20-sec breath-hold through the target volume using a pitch of 6 (high-speed mode). This late arterial scan acquisition phase is referred to as the pancreatic phase . After this acquisition, the patient is asked to inhale and exhale deeply. Another breath-held acquisition is obtained during the portal venous phase (i.e., 70 sec after injection initiation) through the entire liver and upper abdomen using 5-mm nominal thickness sections and a pitch of 6 (high-speed mode). The images obtained during the

pancreatic phase are reconstructed at 0.5-mm intervals using a 20-cm field of view. These data are then transferred to aworkstation (Advantage Windows; General Electric Medical Systems).Curved planar reformations are obtained by interactively placing a cursor on a stack of axial, sagittal, coronal, or oblique sections along the course of a specific plane is the voxel dimension perpendicular to the curved plane and depends on the orientation of the section on which it is drawn. The section thickness of the curved plane will never be larger than the effective section thickness or smaller than the transverse pixel dimensions.

2.8 Previous studies

Basnet, et al 2011 Had done a morphometric study of pancreas among Nepalese population . Their study was carried out to establish a normal dimension of pancreas Thus, a descriptive type of study was done within a period of eight years of time (2004 -2011) on 40 pancreases of both sexes and different age groups, collected from embalmed cadavers from four medical colleges of Kathmandu, Nepal. The obtained specimens of pancreas were classified according to the age and sex. Simultaneously, the weight and length were measured. The data was statistically analyzed and compared, which revealed that the mean size of pancreas was significantly larger in below forty years of age group. Although, there was no significant difference in the size of pancreas between male and female, the pancreas of male subjects was found larger. Thus, the result of the present study not only provides that the pancreas is larger in younger people and males Basnet, et al 2011).

Arslan et al 2010 had proposed Obesity as a risk factor for pancreatic cancer, pooled data were analyzed from the National Cancer Institute Pancreatic Cancer Cohort Consortium (PanScan) to study the association between prediagnostic anthropometric measures and risk of pancreatic cancer. PanScan applied a nested case-control study design and included 2170 cases and 2209 control subjects. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated using unconditional logistic regression for cohortspecific quartiles of body mass index (BMI [calculated as weight in kilograms divided by height in meters squared]), weight, height, waist circumference, and waist to hip ratio as well as conventional BMI categories (underweight, 18.5; normal weight, 18.5-24.9; overweight, 25.0-29.9;obese, 30.0-34.9; and severely obese,>35.0). Models were adjusted for

potential confounders. In all of the participants, a positive association between increasing BMI and risk of pancreatic cancer was observed (adjusted OR for the highest vs lowest BMI quartile, 1.33; 95% CI, 1.12-1.58; *P*trend_.001). In men, the adjusted OR for pancreatic cancer for the highest vs lowest quartile of BMI was 1.33 (95% CI, 1.04-1.69; *P*trend_.03), and in women it was 1.34 (95% CI, 1.05-1.70; *P* trend=.01).Increased waist to hip ratio was associated with increased risk of pancreatic cancer in women (adjusted OR for the highest vs lowest quartile, 1.87; 95% CI, 1.31-2.69;*P* trend=.003) but less so in men. The authors Concluded that their findings provide strong support for a positive association between BMI and pancreatic cancer risk. In addition, centralized fat distribution may increase pancreatic cancer risk, especially in women. (Arslan et al. 2010).

Association between body mass index (BMI: kg/m^2) and pancreatic cancer risk in Asian populations also had done by Kristin E. Anderson, 2014 ,they examined this relationship in 51,251 Chinese men and women aged 45–74 who enrolled between 1993 and 1998 in the population based, prospective Singapore Chinese Health Study. Data were collected through in-person interviews. 194 cohort participants had developed pancreatic cancer. A Cox proportional hazards model was used to estimate hazard ratios (HR) and their 95% confidence intervals (95% CI). They hypothesized the association between BMI and pancreatic cancer risk may vary by smoking status (ever v. never) and there was evidence for this as the interaction between BMI and smoking status was significant (p = 0.018). Among ever smokers, being classified as underweight (BMI <18.5 kg/m^2), was associated with a significantly elevated risk of pancreatic cancer relative to smokers with a BMI of 21.5–24.4 kg/m^2 (HR = 1.99, 95% CI = 1.03–3.84). This association was strengthened after exclusion of the first three years of

follow-up time. Among never smokers, there was no association between BMI and pancreatic cancer risk. However, after excluding pancreatic cancer cases and person-years in the first three years of follow-up, never smokers with a BMI $\geq$ 27.5 kg/m^2 showed a suggestive increased risk of pancreatic cancer relative to never smokers with a BMI of 21.5–24.4 kg/m^2 (HR = 1.75, 95% CI = 0.93–3.3). In conclusion, Singaporean Chinese who were underweight with a history of smoking had an increased risk of developing pancreatic cancer, whereas there was no significant association between BMI and pancreatic cancer in never smokers (Kristin E. Anderson, 2014).

Heuck et al, 1987 performed abdominal computed tomographic scans on a group of 360 patients between the ages of 20 and 80 years. The anteroposterior diameter of the pancreatic head, body, and tail, the age-related ratio of vertebral body-pancreas diameter, and the external and internal contours of the organ were analyzed. The age-related changes in the pancreas were compared with known anatomical findings. External contour of the pancreas show that pancreatic lobulation increase not only in frequently with age but also in degree ;and with advance age a lobular outer contour is common ,Internal structure of the pancreas also changes with age .a homogeneous structure is almost exclusively to one 3rd decade ,by 4th decade patchy structure to one third of pancreas and increase with age. Anteroposterior pancreas diameter affected with age ,an increasing reduction of anteroposterior diameter of pancreatic head ,body, and tail (Heuck et al, 1987).

Kreel L, et al 1977 demonstrate the normal anatomy of the pancreas by using computed tomography (CT) (EMI) in 50 patients with no known pancreatic disease and in15comparable postmortem studies. The size of the normal pancreas was found to be up to 3.0 cm for the head, 2.5 cm for the

neck and body, and 2.0 cm for the tail. In assessing these values, it is important to be sure that adjacent structures such as the portal vein, splenic vein, and duodenum are not included in the measurement, that the measurements are taken on scans of maximum resolution with no movements, and that the measurements are strictly related to the anteroposterior diameter. It is considered that gantry tilt will also distort these figures (Kreel L, et al 1977).

The density , contour and thickness of the pancreas in diabetics were measured CT findings in 57 patients, studied by JP Gilbeau et al, 1992. group of diabetics were examend;20 insulin dependent pt,25 type 2{not treated},12 treated with but not depended on it.57 control subjects with similar in age to those of diabetics patient .CT shows reduction in size and increase in lobulations , especially on insulin treated pts , but no change in density of them.size did not correlate with age, body mass index or the duration of diabetes. They conclude that the pancreas is a smaller organ in patients with diabetes insulin-dependent/insulin-deficient subjects (JP Gilbeau et al, 1992).

Ncyan J et al, 2001 to determine the optimal phase for enhancement of the normal pancreas and peripancreatic vasculature and the maximal tumor-to-pancreatic parenchymal enhancement difference by using multiphase, contrast material–enhanced, multi–detector row helical computed tomography (CT).Forty-nine patients with a normal-appearing pancreas but suspected of having pancreatic abnormality and 28 patients with proved pancreatic adenocarcinoma underwent multiphase, contrast-enhanced, multi–detector row CT during the arterial phase (AP), pancreatic parenchymal phase (PPP), and portal venous phase (PVP). Attenuation values of the normal pancreas, pancreatic adenocarcinoma, celiac and

superior mesenteric arteries, and superior mesenteric and portal veins were measured during all three imaging phases. Quantitative analysis of these measurements and subjective qualitative analysis of tumor conspicuity were performed. Their result says maximal enhancement of the normal pancreatic parenchyma occurred during the PPP. Maximal tumor-to-parenchyma attenuation differences during the PPP and PVP were equivalent but greater than that during the AP. Subjective analysis revealed that tumor conspicuity during the PPP and PVP was equivalent but superior to that during the AP. Maximal arterial enhancement was seen during the PPP, and maximal venous enhancement was seen during the PVP (Ncyan J et al, 2001).

According to RaviRajput et al, 2001 reports ,the findings were that the total area of the pancreas was significantly smaller in patients with type 1 diabetes mellitus when compared with healthy controls and with increasing duration of diabetes there was a reduction of the dimensions of the head, body, tail and total area of pancreas which are more evident if diabetes is of more than 10 years duration (RaviRajput et al, 2001).

Abhishek Mathur et al, 2003 introduce that ,Increased visceral fat and pancreatic steatosis promote lymphatic metastases and decreased survival in patients with pancreatic adenocarcinoma after pancreatoduodenectomy (PD).Authers aim to determine the utility of preoperative computed tomography (CT) measurements of pancreatic steatosis and visceral fat as prognostic indicators in patients with pancreatic adenocarcinoma.High-resolution CT scans of 42 patients undergoing PD for pancreatic adenocarcinoma were reviewed. Attenuation in CT of the pancreas, liver and spleen were measured in Hounsfield units and scored by two blinded investigators. Perirenal adipose tissue was measured in mm. The Lymphatic metastases were present in 57% of patients. Age, gender, tumour size and

margin status were similar in patients with and without nodal metastases. Node-positive patients had increased visceral but not subcutaneous fat pads compared with node-negative patients and decreased CT attenuation of the pancreatic body and tail and liver. Node-positive patients stratified by visceral adiposity (≥10 mm vs. <10 mm) demonstrated poorer survival (7 ± 1 months vs. 16 ± 2 months; $P < 0.01$).heir conclusions demonstrate that In resected pancreatic adenocarcinoma, increased pancreatic steatosis and increased visceral fat stores are associated with lymphatic metastases. Furthermore, increased visceral fat is associated with abbreviated survival in patients with lymphatic metastases. Hence, increased visceral fat may be a causative factor of abbreviated survival and serves a prognostic role in patients with pancreatic malignancies (Abhishek Mathur et al, 2003).

George Štefánek, 2011 measured the sizes (widths) in pancreas, and found that Pancreatic head is < 30mm, Pancreatic body < 20mm, Pancreatic tail < 25mm, Pancreatic duct < 2mm (George Štefánek, 2011).

Xiu-Zhong Yao et al, 2014 aimed to optimize diffusion-weighted imaging (DWI) acquisitions for normal pancreas at 3.0 Tesla. Thirty healthy volunteers were examined using four DWI acquisition techniques with b values of 0 and 600 s/mm2 at 3.0 Tesla, including breath-hold DWI, respiratory-triggered DWI, respiratory-triggered DWI with inversion recovery (IR), and free-breathing DWI with IR. Artifacts, signal-to-noise ratio (SNR) and apparent diffusion coefficient (ADC) of normal pancreas were statistically evaluated among different DWI acquisitions. Statistical differences were noticed in artifacts, SNR, and ADC values of normal pancreas among different DWI acquisitions by ANOVA ($P < 0.001$).

Normal pancreas imaging had the lowest artifact in respiratory-triggered DWI with IR, the highest SNR in respiratory-triggered DWI, and the highest ADC value in free-breathing DWI with IR. The head, body, and tail of normal pancreas had statistically different ADC values on each DWI acquisition by ANOVA ($P < 0.05$). Their conclusion demonstrates highest image quality for normal pancreas was obtained using respiratory-triggered DWI with IR. Normal pancreas displayed inhomogeneous ADC values along the head, body, and tail structures (Xiu-Zhong Yao et al, 2014).

Schlumpf et al, 1989 to determine end-stage size of the graft and to evaluate magnetic resonance imaging (MRI) and computed tomography (CT), these imaging techniques were applied in eight patients with well-functioning intraperitoneal prolamine-injected segmentalpancreas transplants for 79, 48, 35, 20, 19, 19, 18, and 10 mo. MRI was performed on a 1.5 Tesla system (Philips Gyroscan S15). T1- and T2-weighted images were acquired. CT (Siemens Somatom 2) was done before and after intravenous contrast agent. The graft was visualized in seven of eight patients with both techniques. Visualization with MRI (vs. CT) was considered excellent in 2 (vs. 1), good in 3 (vs. 6), and poor in 2 (vs. 0). The three grafts with function longer than 2 yr measured 3-4 cm in length; the remaining grafts measured 3-6 cm. Because of a marked decrease in size the transplants were no longer localized in Douglas' pouch but adjacent to or on top of the uterus or bladder, the position depending on the volume of these organs. The a I log rafts exhibited an inhomogeneous structure with casual cystic degeneration visible with MRI due to a high signal intensity on T2-weighted images. This study suggests that shrinkage of the duct-occluded pancreatic segment due to exocrine atrophy may be terminated after ~2 yr. It is concluded that

thereafter an overshooting fibrosis causing late endocrine graft failure may not be anticipated (Schlumpf et al, 1989).

Roxana Şirli, 2010 Saied that the pancreas is a challenge for the beginner in ultra sonography, but patience, perseverance and experience will lead to a complete and correct evaluation of the organ in almost all cases .A correct examination of the pancreas requires the patient's fasting 7 to 8 hours before the amination .Transverse and longitudinal upper epigastric sections are used to visualize the pancreas, as well as oblique intercostal and subcostal sections (especially for the head and tail). The best ultrasound windows are obtained by using high epigastric sections (that avoid the colon), also by using transgastric sections and sections that use the left liver lobe as an acoustic window. In order to better visualize the pancreas, it is useful to invite the patient to drink 500-700 ml of still water 10-15 minutes before the examination. To highlight the pancreas, we will start by viewing the landmarks: posterior – the porto-splenic axis and anterior – the gastric antrum and/or the left liver lobe. The echogeneity of the normal pancreas can vary, from hypoechoic to hyperechoic,all normal, provided that the pancreatic parenchyma structure is fine and homogeneous. The Wirsung duct can be visualized in some of the cases, especially in thin patients, its normal maximum diameter should be < 2mm.For a correct evaluation of the pancreas all its segments must be visualized: head, uncinate process, body, and tail – the latter being the most difficult to visualize (Roxana Şirli, 2010).

Many authors' used ultra sound in their pancreatic study. Alzaid etal, 1993 to determine whether there was an association between the size of the pancreas and the type of diabetes, , ultrasonography of the pancreas was performed on 57 diabetic patients: 14 with Type 1 (insulin-dependent) diabetes, 10 insulin-treated and 33 tablet-treated patients with Type 2 (non-

insulin-dependent) diabetes, and 19 non-diabetic subjects. The pancreas of patients with Type 1 diabetes was markedly smaller ($p < 0.0001$) than the pancreas in non-diabetic subjects. The pancreas of patients with Type 2 diabetes was more moderate in size: larger ($p < 0.001$) than that of Type 1 diabetic patients but smaller ($p < 0.5$) than the pancreas of the control group. Pancreatic size of patients with Type 2 diabetes was also related to basal insulin secretion with insulin-deficient patients (low or undetectable C-peptide) having smaller ($p < 0.05$) pancreases than those with normal insulin secretion. There was no difference in the size of the pancreas in the different treatment groups of Type 2 diabetic patients. Pancreatic size did not correlate with age, body mass index or the duration of diabetes. We conclude that the pancreas is a smaller organ in patients with diabetes mellitus and that the decrement in size is maximal in insulin-dependent/insulin-deficient subjects. Ultrasonography, therefore, can potentially serve to discriminate between the different types of diabetes (Alzaid etal, 1993).

Reza Basiratnia, 2007 had studied the Ultrasonographic alterations of pancreas in diabetic patients. Pancreas as the insulin-producing gland is subjected to destruction and change in the diabetes-producing process. Real-time sonography can assess the gland in 95% of cases and its accuracy in diagnosis of pancreatic disease matches that of CT-scan. Reza The purpose of this study was to evaluate pancreatic diameter and echogenicity by sonography and to examine the correlation of these two factors with duration of disease in diabetes types I and II in comparison with controls. In two groups of 60 diabetic patients and healthy controls, diameter and echogenicity of pancreas was determined. They described that diameter of pancreas was significantly different in diabetic patients and correlated with duration of disease. In type I diabetes, decrease in the size of pancreas was

more prevalent than in type II diabetes and these changes become more prominent over time. (Reza Basiratnia, 2007).

Br Med J, 1985 determined the Size of pancreas in diabetes mellitus, the study based on ultrasound the results show that the pancreas is significantly smaller in diabetic patients than in healthy controls (Br Med J, 1985).

Lucia Veştemean et al, 2011 they mentioned that Since a competent abdominal ultrasound requires a good view of the pancreas we propose tracking the sizes of the head of the pancreas in the healthy child ,the sizes of the spleen (transverse and longitudinal diameter) and the establishment of any parallels in the development of both organs. The results of this study indicate an increase in spleen length and anterior-posterior diameter of the head of the pancreas in the dynamics of age. Increased anterior-posterior diameter was lower in the first three years of life and presented variations. The anterior-osterior diameter of the head of the pancreas correlated with the subject's height was good (r = 0.37), which may be selected for use in establishing normal charts. Slower growth in the anterior-posterior diameter of the pancreatic head compared with faster growth rates of the length and the transverse diameter of the spleen calls for different growth rates of the two.Because of various types of morphological changes in pancreas have been demonstrated in patients with type 1 diabetes mellitus. Ravi Rajput et al 2001 were evaluate 35 patients suffering from type 1 diabetes mellitus and compared them with 15 age, sex and BMI matched healthy controls to access the morphology of the pancreas by ultrasonography which is non-invasive, economic, simple and easily available. It was found that patients with type 1 diabetes mellitus have a reduction in total area of the pancreas, increased diameter of the main pancreatic duct and presence of fibrosis and

calcification which was more pronounced in patients having longer duration of diabetes (Lucia Veştemean et al, 2011).

The aim of Emma Altobelli et al 2010 study, was to evaluate the influence of insulin-dependent diabetes mellitus (IDDM) on the size of the pancreas in children. Pancreas size was evaluated sonographically in a group of 60 diabetic children and adolescents, aged 3–15 years, and 60 sex- and age-matched healthy controls. A significant reduction in pancreatic area and other parameters was found in diabetic patients, particularly in children aged 8–12 and 13–15 years. The pancreas was larger in children 3–7 years old who had had IDDM for 2 years of less (mean size, 8.61 cm^2) than in children 8–12 and 13–15 years old who had had IDDM for more than 5 years (mean size, 8.06 and 8.40 cm^2, respectively). An inverse correlation between area of the pancreas and duration of IDDM was seen in all age groups ($p < 0.05$). Diabetes affects the growth of the pancreas in children with IDDM. Sonography can be used to noninvasively evaluate the influence of the disease on pancreas size (Emma Altobelli et al 2010).

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Study Design

This was descriptive analytical study. It was achieved at radiology department Ebn-Elhitham Hospital Khartoum-Sudan and Alamal Hospital during the period from 2011 to 2015.

3.2 Sample

3.2.1 Inclusion Criteria

A total of 283 patients were included in this study (252) were normal, their mean age was 40.37±16.05years and (31) were diabetic with mean age 55.16±11.07. Patients were in both genders, patients were selected for abdominal CT, CT KUB, and CTU. Patients age, gender, weight, height, abdominal circumference (AC), body mass index (BMI), pancreases head CT number, pancreas body CT number, pancreas Tail CT number, pancreas head size, pancreas body size, pancreas tail size, vertebral body width vertebral body CT number, spleen CT number, for both normal and diabetes group as well as diabetic duration for the affected patients were recorded. Measurement were made and comparison took place between the normal control group and affected patients. Diabetic patients were treated either by tablets (non insulin dependent) or insulin subcutaneously injected (insulin dependent).

3.2.2 Exclusion criteria:

Patients having pathological changes such as; ascetics, Retro peritoneal mass, Ca head of pancreas, Pancreatitis or any pathology affecting the measurement of the pancreas were excluded.

3.3 Methods

3.3. 1 Scanning Protocol

252 Sudanese subjects who were scanned for abdomen CT and were diagnosed as normal pancreas and had no history of diabetes or disease affected pancreas were included, in addition to 31 diabetic subjects. Axial images were obtained using Toshiba 4 slice CT scanner Asetation AS 2010 and Toshiba 64 medical system corp, Tokyo, Jaban. Iodinated contrast medium at a dose of 2 mgI kg–1 of body weight was injected.

CT scans were obtained with the patient in a supine position during full inspiration. The scan range was from the lung base to the lower margin of the iliac crest. The exposure parameters were 120 kVp and 250 mA.

3.3.2 Method of Pancreas Measurement

The measurements were taken from the operator council of the CT machine, the axial images were obtained through the middle of the pancreatic portion (head, body and tail) being studied, anter-posterior (AP) measurements of the body and tail thickness perpendicular to the long axis of the organ were made in (mm). Measurements of AP thickness of the pancreatic head were typically performed in the true AP dimensions. The transverse diameter of the adjacent vertebral body was measured and used as a reference as applied by Andreas, 1987. The CT numbers for the pancreas head, body and tail were measured and named as pancreas texture (measured in Hounsfield Unit). The CT number of spleen and vertebra were also been evaluated as references.

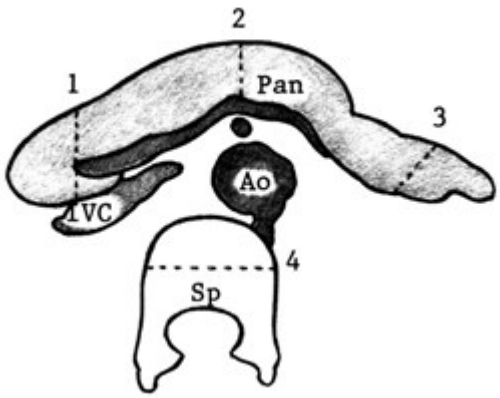

Figure 3.1 shows the method of pancreas measurements

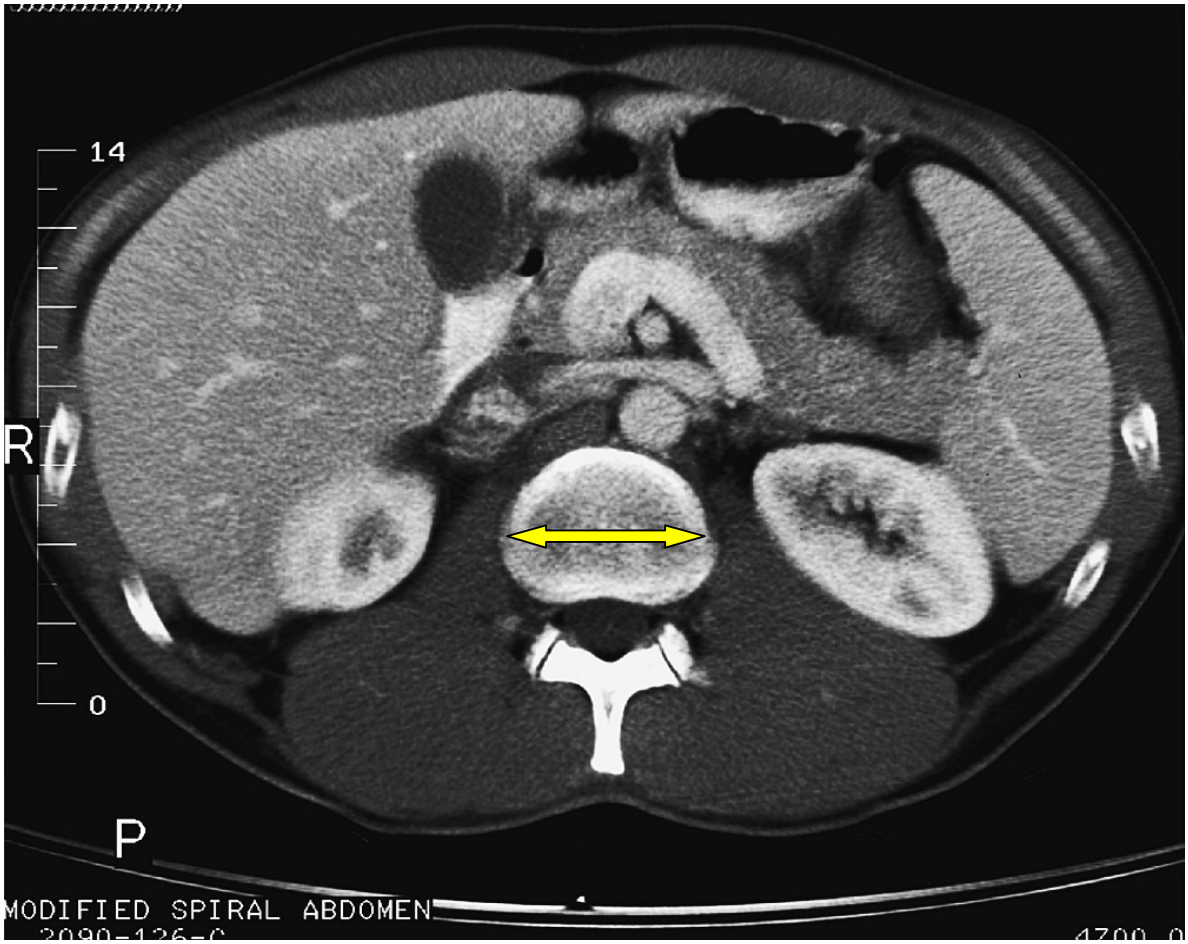

Figure 3.2 Axial CT for abdomen shows the vertebral width as reference plane (yellow arrow)

3.3 3.calibar

3.3.4 Meter

3.Statistical Analyses

The data were collected in master data sheet and were analyzed using SPSS progamme version 16. Data were presented as mean and standard deviation (SD) for all of the variables .Comparisons between groups showed results which were significant at $p < 0.05$ .Detailed results are shown in the tables and figures.

Chapter Four

Result

Chapter Four

RESULTS

Computerized Tomography Scanning was performed in the Radiology Unit of the Ebn Elhaitham and Alamel Centers in Khartoum-Sudan.

The data was collected from 252 normal subjects and were considered as group (A). 31 patients had preexisting diabetes and considered as group (B). patients age, weight, height, abdominal circumference (AC), body mass index (BMI), pancreases head CT number, pancreas body CT number, pancreas tail CT number, pancreas head size, pancreas body size, pancreas tail size, vertebral body width vertebral body CT number, spleen CT number, for both normal and diabetes group as well as diabetic duration for the affected patients were recorded. Measurement were made and comparison took place between the normal control group and affected patients. Data were presented as mean and standard deviation (SD) for all of the variables. Comparisons between groups showed results which were significant at $p < 0.005$ .Detailed results are shown in the tables and figures below.

Group	*Frequency*	*Percent(%)*
Case	31	11.0
Control	252	89.0
Total	283	100%

Table (4.1): Distribution of sample size according to (Case & Control)

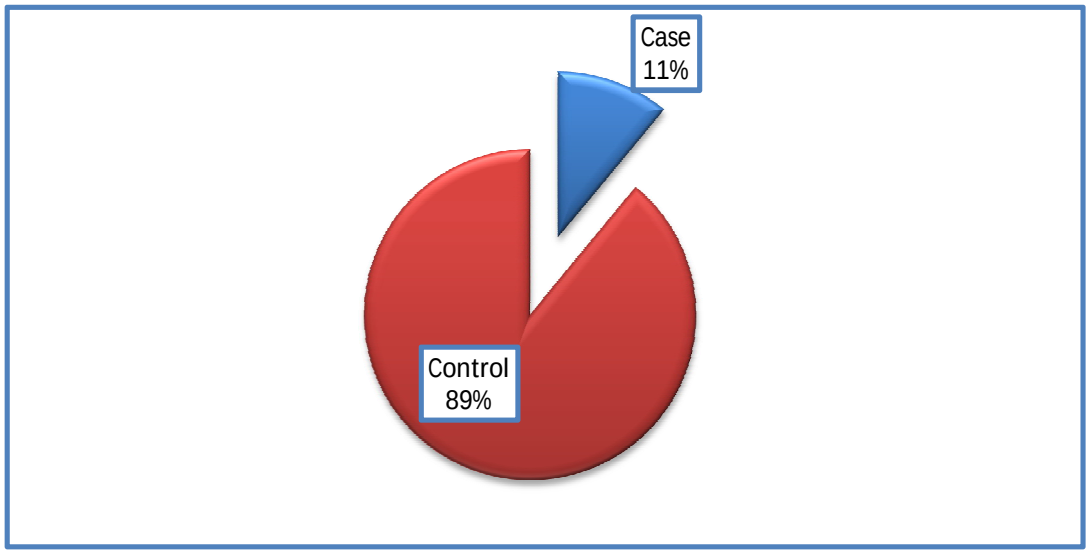

Figure (4.1) : Distribution of sample size according to (Case & Control)

Table (4.2) : Distribution of sample size according to (Gender) Comparison between (Case & Control):

Gender	Case		Control	
	Frequency	*Percent(%)*	*Frequency*	*Percent(%)*
Male	18	58.1	173	68.7
Female	13	41.9	79	31.3
Total	31	100%	252	100%

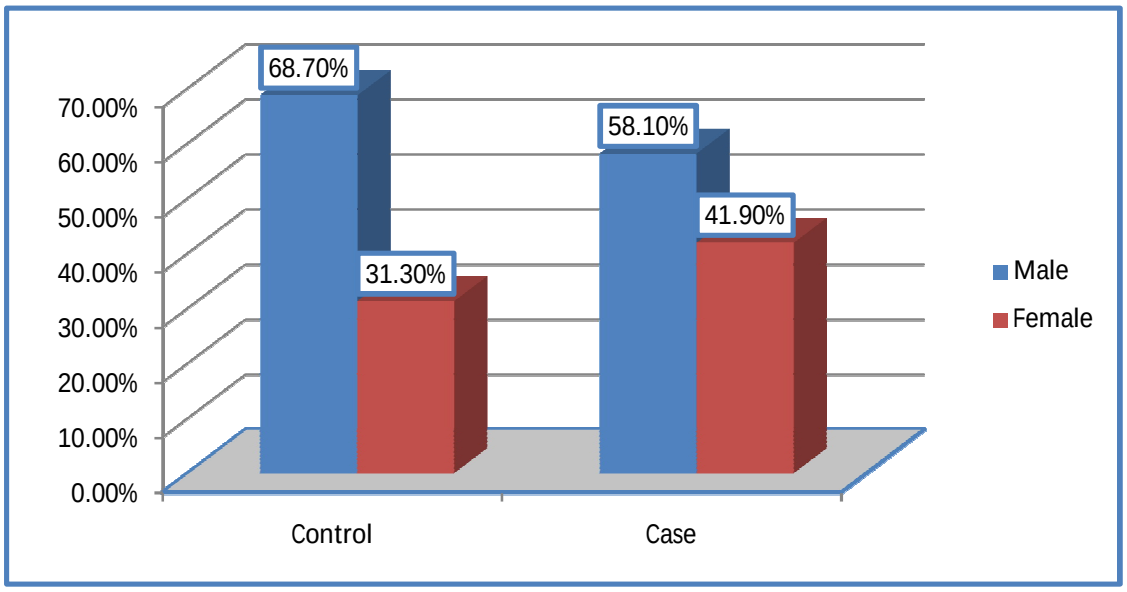

Figure (4.2) : Distribution of sable size according to (Gender) Comparison between (Case & Control)

Table (4.3) : Distribution of sample size according to (age) for (Case & Control)

Age	Case		Control	
	Frequency	*Percent(%)*	*Frequency*	*Percent(%)*
<10	0	0	7	2.8
11-20	0	0	13	5.2
21-30	0	0	54	21.4
31-40	3	9.7	62	24.6
41-50	9	29.0	54	21.4
>51	19	61.3	62	24.6
Total	31	100%	252	100%

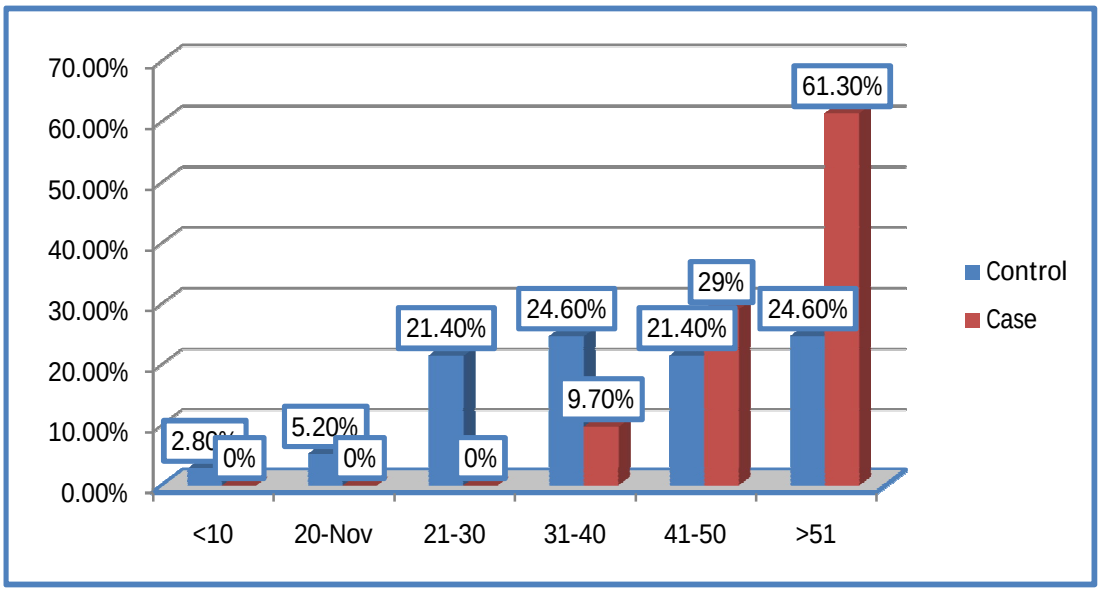

Figure (4.3) : Distribution of sample size according to (age) for (Case & Control)

Table 4.4 Descriptive Statistics (mean and SD)of the variables for both the Normal Control group (Group A)and Diabetes Patients(Group B)

Descriptive Statistics of The Variables						
	(Group B)			***(Group A)***		
	Diabetes Group			Normal Group		
	N	Mean	Std. D	N	Mean	Std. D
Age/Years	31	55.19	11.07	252	40.37	16.05
Weight/Kg	31	75.80	11.88	252	169.41	67.79
Height/Meter	31	166.25	10.69	252	70.08	18.30
Abdominal Circumference(AC)	31	96.29	14.63	252	87.21	19.19
Body mass index(BMI)	31	27.60	5.29	252	27.16	17.57
Pancreas Head CT Number	31	53.16	13.14	252	59.02	14.17
Pancreas Body CT Number	31	49.19	13.97	252	57.22	12.59
Pancreas Tail CT Number	31	45.76	16.04	252	55.44	13.12
Pancreas Head size	31	26.42	2.91	252	28.16	4.87
Pancreas Body size	31	20.97	3.36	252	23.19	3.74
Pancreas Tail size	31	17.34	3.31	252	19.05	3.05
Vertebral Body Width	31	39.83	3.82	252	38.62	4.04
Vertebral Body CT Number	31	229.93	56.82	252	254.15	51.60
Spleen CT Number	31	57.48	15.48	252	59.55	13.62
Diabetic Duration	31	7.12	5.42			

Table (4.5) : ANOVA test shows the Association between (Measurements) according to age groups for normal Sudanese subjects(control)Group(A)

		N	Mean	Std. Deviation	Minimum	Maximum	P –value
Pancreas Head CT Number	<10	7	57.7143	7.29644	48.00	67.00	.054
	11-20	13	59.0692	11.09485	27.90	71.00	
	21-30	54	62.5685	16.83473	35.00	135.00	
	31-40	62	58.2754	14.15735	39.00	137.00	
	41-50	54	61.4472	15.34120	27.70	98.00	
	>51	62	54.7484	10.55072	29.00	88.00	
	Total	252	59.0260	14.17632	27.70	137.00	
Pancreas body CT Number	<10	7	57.5714	6.39940	50.00	68.00	*0.000*
	11-20	13	61.3333	5.91352	52.00	73.00	
	21-30	54	62.3000	13.74840	29.00	115.00	
	31-40	62	56.4161	10.98643	38.00	107.00	
	41-50	54	59.1019	13.36985	40.00	96.00	
	>51	62	51.1387	11.47204	13.00	96.50	
	Total	252	57.2235	12.59123	13.00	115.00	
Pancreas Tail ct	<10	7	56.0000	6.16441	49.00	69.00	*0.000*
	11-20	13	60.7923	6.96138	53.00	80.00	
	21-30	54	59.3870	14.21272	25.00	97.00	
	31-40	62	55.7774	11.59879	37.00	101.00	
	41-50	54	57.0278	13.60736	40.00	91.00	
	>51	62	49.0213	12.67044	10.00	83.00	
	Total	252	55.4470	13.12100	10.00	101.00	
Pancreas Head size	<10	7	19.8571	4.22132	13.10	25.80	*0.000*
	11-20	13	30.3000	11.25256	23.50	66.90	
	21-30	54	28.1500	3.60622	18.40	39.40	
	31-40	62	28.4887	2.80147	22.20	35.00	
	41-50	54	29.1852	4.39577	20.60	54.00	
	>51	62	27.4435	4.98133	20.60	58.00	
	Total	252	28.1619	4.87676	13.10	66.90	
Pancreas Body size	<10	7	17.9143	3.42366	13.80	22.80	*0.000*
	11-20	13	20.5385	3.57341	15.50	25.80	
	21-30	54	22.7778	4.04543	12.60	34.10	
	31-40	62	24.4161	3.81164	13.30	36.50	
	41-50	54	23.9630	2.97057	18.00	35.00	
	>51	62	22.8145	3.25374	15.00	33.00	
	Total	252	23.1933	3.74500	12.60	36.50	
Pancreas Tail size	<10	7	14.1714	3.86338	9.70	19.70	*0.000*
	11-20	13	17.1462	2.92621	12.70	21.50	
	21-30	54	18.8148	3.07076	11.00	26.40	
	31-40	62	19.7339	3.15527	10.60	26.90	
	41-50	54	19.7704	2.46068	14.00	26.20	
	>51	62	18.9065	2.70312	13.50	30.50	
	Total	252	19.0532	3.05397	9.70	30.50	

Vertebral Body Width	<10	7	29.7571	5.85544	22.00	40.00	*0.000*
	11-20	13	35.6692	3.15367	29.80	39.30	
	21-30	54	38.4870	3.67532	28.20	44.50	
	31-40	62	39.3161	3.13140	32.00	46.00	
	41-50	54	39.4185	3.92952	30.00	50.70	
	>51	62	38.9823	3.85115	24.00	45.70	
	Total	252	38.6246	4.04104	22.00	50.70	
Vertebral Body CT Number	<10	7	268.8429	38.27975	222.00	330.00	*0.000*
	11-20	13	271.8462	37.93162	220.00	353.00	
	21-30	54	273.2778	43.89155	201.00	380.00	
	31-40	62	263.9194	43.29741	190.00	444.00	
	41-50	54	254.0556	55.70997	150.00	444.00	
	>51	62	222.4419	52.43898	78.00	336.00	
	Total	252	254.1520	51.60139	78.00	444.00	
Spleen CT Number	<10	7	53.4286	2.82000	50.00	57.00	.179
	11-20	13	62.9231	7.28539	55.00	76.00	
	21-30	54	62.7981	14.89160	47.00	118.00	
	31-40	62	60.2016	11.00887	45.00	111.00	
	41-50	54	58.1755	17.42435	5.00	114.00	
	>51	62	57.2952	12.40759	13.00	121.00	
	Total	252	59.5536	13.62118	5.00	121.00	

Table (4.6) : ANOVA test shows the Association between Measurements) according to age classes for Diabetic patients (Group B)

		N	Mean	Std. Deviation	Minimum	Maximum	P -value
Pancreas Head CT Number	31-40	3	51.0000	7.93725	45.00	60.00	.901
	41-50	9	54.7111	5.15278	48.00	66.00	
	>51	19	52.7789	16.34502	32.00	85.00	
	Total	31	53.1677	13.14748	32.00	85.00	
Pancreas Body CT Number ct	31-40	3	48.0000	2.00000	46.00	50.00	.771
	41-50	9	52.1111	8.05364	40.00	67.00	
	>51	19	48.0000	17.03265	27.00	87.00	
	Total	31	49.1935	13.97240	27.00	87.00	
Pancreas Tail CT Number	31-40	3	40.0000	6.08276	33.00	44.00	.469
	41-50	9	51.1111	10.24017	33.00	69.00	
	>51	19	44.1421	18.85922	8.00	85.00	
	Total	31	45.7645	16.04362	8.00	85.00	
Pancreas Head size (AP diameter)	31-40	3	26.3667	1.66233	24.60	27.90	.283
	41-50	9	53.4000	79.08748	18.10	264.00	
	>51	19	26.1632	2.38961	22.60	33.00	
	Total	31	34.0903	42.76901	18.10	264.00	
Pancreas Body size (AP diameter)	31-40	3	22.9667	1.79258	20.90	24.10	.469
	41-50	9	20.1667	3.72827	15.60	26.00	
	>51	19	21.0368	3.36456	15.80	30.90	
	Total	31	20.9710	3.36276	15.60	30.90	
Pancreas Tail size (AP diameter)	31-40	3	17.6333	1.37961	16.60	19.20	.591
	41-50	9	16.3667	3.67151	11.80	23.50	
	>51	19	17.7632	3.38809	13.10	25.90	
	Total	31	17.3452	3.31892	11.80	25.90	
Vertebral Body Width	31-40	3	36.8000	1.05357	35.80	37.90	.018
	41-50	9	37.7222	2.80525	33.50	42.30	
	>51	19	41.3105	3.83491	36.90	49.60	
	Total	31	39.8323	3.82565	33.50	49.60	
Vertebral Body CT Number	31-40	3	325.3333	109.29013	227.00	443.00	.001
	41-50	9	246.0000	38.58108	182.00	298.00	
	>51	19	207.2632	34.71606	152.00	280.00	
	Total	31	229.9355	56.82777	152.00	443.00	
Spleen CT Number	31-40	3	51.3333	4.93288	48.00	57.00	.390
	41-50	9	63.2222	16.66417	52.00	100.00	
	>51	19	55.7368	15.74040	36.00	96.00	
	Total	31	57.4839	15.48950	36.00	100.00	

Diabetic Duration	31-40	3	8.3333	6.65833	4.00	16.00	.905
	41-50	9	7.3333	5.50000	1.00	16.00	
	>51	19	6.8421	5.50013	1.00	20.00	
	Total	31	7.1290	5.42059	1.00	20.00	
	31-40	3	8.3333	6.65833	4.00	16.00	
	41-50	9	7.3333	5.50000	1.00	16.00	
	>51	19	6.8421	5.50013	1.00	20.00	
	Total	31	7.1290	5.42059	1.00	20.00	

Table (4.7) : Independent Samples Test shows the Association between (Gender) & (Measurements) for normal Sudanese subjects (Group A)

		N	Mean	Std. Deviation	Minimum	Maximum	P value
Pancreas Head CT number	Male	173	57.8649	13.44373	27.70	137.00	.057
	Female	79	61.5392	15.43669	27.90	111.00	
	Total	252	59.0260	14.17632	27.70	137.00	
Pancreas Body CT number	Male	173	56.3076	10.74453	29.00	97.00	.089
	Female	79	59.2177	15.78510	13.00	115.00	
	Total	252	57.2235	12.59123	13.00	115.00	
Pancreas Tail CT number	Male	173	54.5006	12.36296	10.00	97.00	.089
	Female	79	57.5462	14.52833	13.00	101.00	
	Total	252	55.4470	13.12100	10.00	101.00	
Pancreas Head size	Male	173	28.4075	4.52945	13.10	58.00	.238
	Female	79	27.6241	5.55560	18.50	66.90	
	Total	252	28.1619	4.87676	13.10	66.90	
Pancreas Body size	Male	173	23.3902	3.48434	12.60	36.50	.217
	Female	79	22.7620	4.25273	13.30	33.00	
	Total	252	23.1933	3.74500	12.60	36.50	
Pancreas Tail size	Male	173	19.1844	2.96496	9.70	26.90	.314
	Female	79	18.7658	3.24128	10.60	30.50	
	Total	252	19.0532	3.05397	9.70	30.50	
Vertebral Body Width	Male	173	39.5445	3.94104	22.00	50.70	.000
	Female	79	36.6101	3.50891	28.20	49.90	
	Total	252	38.6246	4.04104	22.00	50.70	
Vertebral Body CT Number	Male	173	261.8665	52.47390	78.00	444.00	.000
	Female	79	237.2582	45.55815	108.00	370.00	
	Total	252	254.1520	51.60139	78.00	444.00	
Spleen CT Number	Male	173	58.0802	12.07563	5.00	114.00	.011
	Female	79	62.8026	16.14322	44.00	121.00	
	Total	252	59.5536	13.62118	5.00	121.00	
	Female	12	1.6667	.98473	1.00	4.00	
	Total	30	1.2667	.69149	1.00	4.00	

Table (4.8) : Independent Samples Test shows the Association between (Gender) & (Measurements)for diabetes (Group B)

		N	Mean	Std. Deviation	Minimum	Maximum	P -value
Pancreas Head CT number	Male	18	54.2778	15.27322	32.00	85.00	.589.
	Female	13	51.6308	9.86233	40.20	79.00	
	Total	31	53.1677	13.14748	32.00	85.00	
Pancreas Body CT number	Male	18	50.5556	15.06153	34.00	87.00	532
	Female	13	47.3077	12.65164	27.00	77.00	
	Total	31	49.1935	13.97240	27.00	87.00	
Pancreas Tail CT number	Male	18	46.9833	18.52700	8.00	85.00	.627
	Female	13	44.0769	12.32519	24.00	70.00	
	Total	31	45.7645	16.04362	8.00	85.00	
Pancreas Head size	Male	18	40.3833	55.86147	22.60	264.00	.344
	Female	13	25.3769	3.25632	18.10	30.70	
	Total	31	34.0903	42.76901	18.10	264.00	
Pancreas Body size	Male	18	21.8111	3.68876	15.80	30.90	.102
	Female	13	19.8077	2.54344	15.60	24.00	
	Total	31	20.9710	3.36276	15.60	30.90	
Pancreas Tail size	Male	18	18.0611	3.59348	13.10	25.90	.161
	Female	13	16.3538	2.72232	11.80	21.00	
	Total	31	17.3452	3.31892	11.80	25.90	
Vertebral Body Width	Male	18	41.4278	4.05735	35.80	49.60	.004
	Female	13	37.6231	2.04008	33.50	40.40	
	Total	31	39.8323	3.82565	33.50	49.60	
Vertebral Body CT Number	Male	18	242.3333	61.35336	174.00	443.00	.156
	Female	13	212.7692	46.80839	152.00	298.00	
	Total	31	229.9355	56.82777	152.00	443.00	
Spleen CT Number	Male	18	57.7222	14.79589	36.00	96.00	.922
	Female	13	57.1538	17.01395	37.00	100.00	
	Total	31	57.4839	15.48950	36.00	100.00	
Diabetic Duration	Male	18	7.0556	5.96531	1.00	20.00	.931
	Female	13	7.2308	4.79850	1.00	16.00	
	Total	31	7.1290	5.42059	1.00	20.00	

Table (4.9) Correlations between the Pancreas Characteristics and Body characteristics for the Normal Control group (Group A)

		Head CT Number	***Body CT Number***	***Tail CT Number***	***Head size***	***Body size***	***Tail size***
Age/Years	Pearson Correlation	-.146(*)	-.280(**)	-.296(**)	.006	.147(*)	.129(*)
	Sig. (2-tailed)	.021	.000	.000	.923	.019	.040
	N	252	252	252	252	252	252
Gender	Pearson Correlation	.145(*)	.119	.116	-.074	-.077	-.063
	Sig. (2-tailed)	.022	.061	.067	.241	.223	.321
	N	252	252	252	252	252	252
Weight/Kg	Pearson Correlation	-.045	-.005	.009	.064	.007	-.018
	Sig. (2-tailed)	.478	.932	.890	.309	.907	.778
	N	252	252	252	252	252	252
Height/meter	Pearson Correlation	-.094	-.138(*)	-.124	.313(**)	.370(**)	.377(**)
	Sig. (2-tailed)	.137	.029	.050	.000	.000	.000
	N	252	252	252	252	252	252
Abdominal Circumference (AC)	Pearson Correlation	-.062	-.153(*)	-.141(*)	.071	.172(**)	.207(**)
	Sig. (2-tailed)	.329	.015	.026	.262	.006	.001
	N	252	252	252	252	252	252
Body mass index(BMI)	Pearson Correlation	-.017	-.055	-.063	.037	.032	-.009
	Sig. (2-tailed)	.789	.382	.317	.556	.609	.886
	N	252	252	252	252	252	252
Vertebral Body Width	Pearson Correlation	-.152(*)	-.130(*)	-.146(*)	.174(**)	.260(**)	.149(*)
	Sig. (2-tailed)	.016	.040	.021	.006	.000	.018
	N	252	252	252	252	252	252
Vertebral Body CT Number	Pearson Correlation	.127(*)	.163(**)	.264(**)	.038	.001	.111
	Sig. (2-tailed)	.045	.010	.000	.550	.985	.078
	N	252	252	252	252	252	252
Spleen CT Number	Pearson Correlation	.511(**)	.548(**)	.597(**)	.082	.005	-.103
	Sig. (2-tailed)	.000	.000	.000	.195	.939	.104
	N	252	252	252	252	252	252

** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).

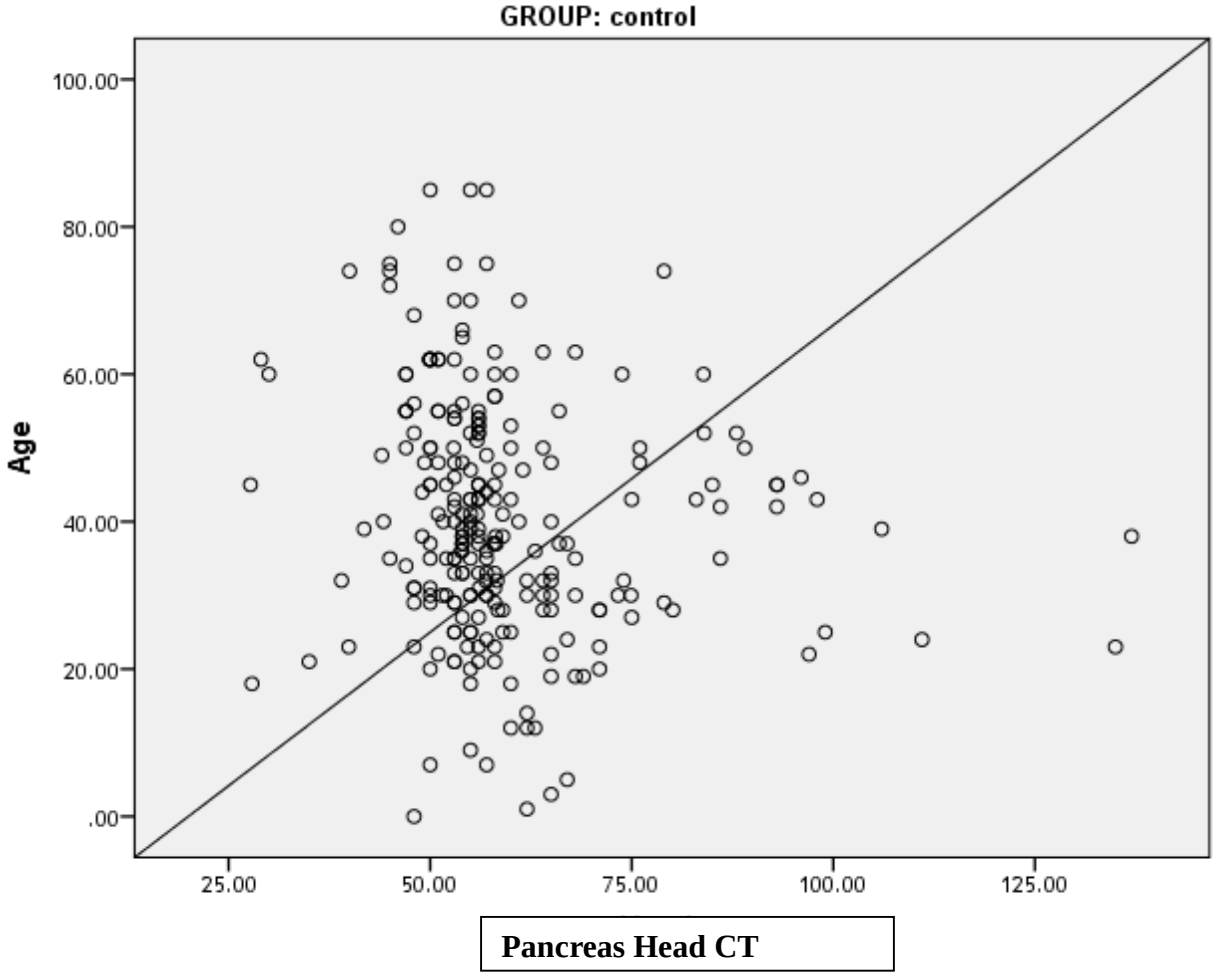

Figure 4.4 A scatter plot diagram shows Linear relationship between the pancreas head CT number and patient age/Years for the control group, The Contribution of age on the CT number of Pancreas is2%

Predictive equation of Pancreas Head CT Number:-

Pancreas Head CT Number=50.102-0.165Xage

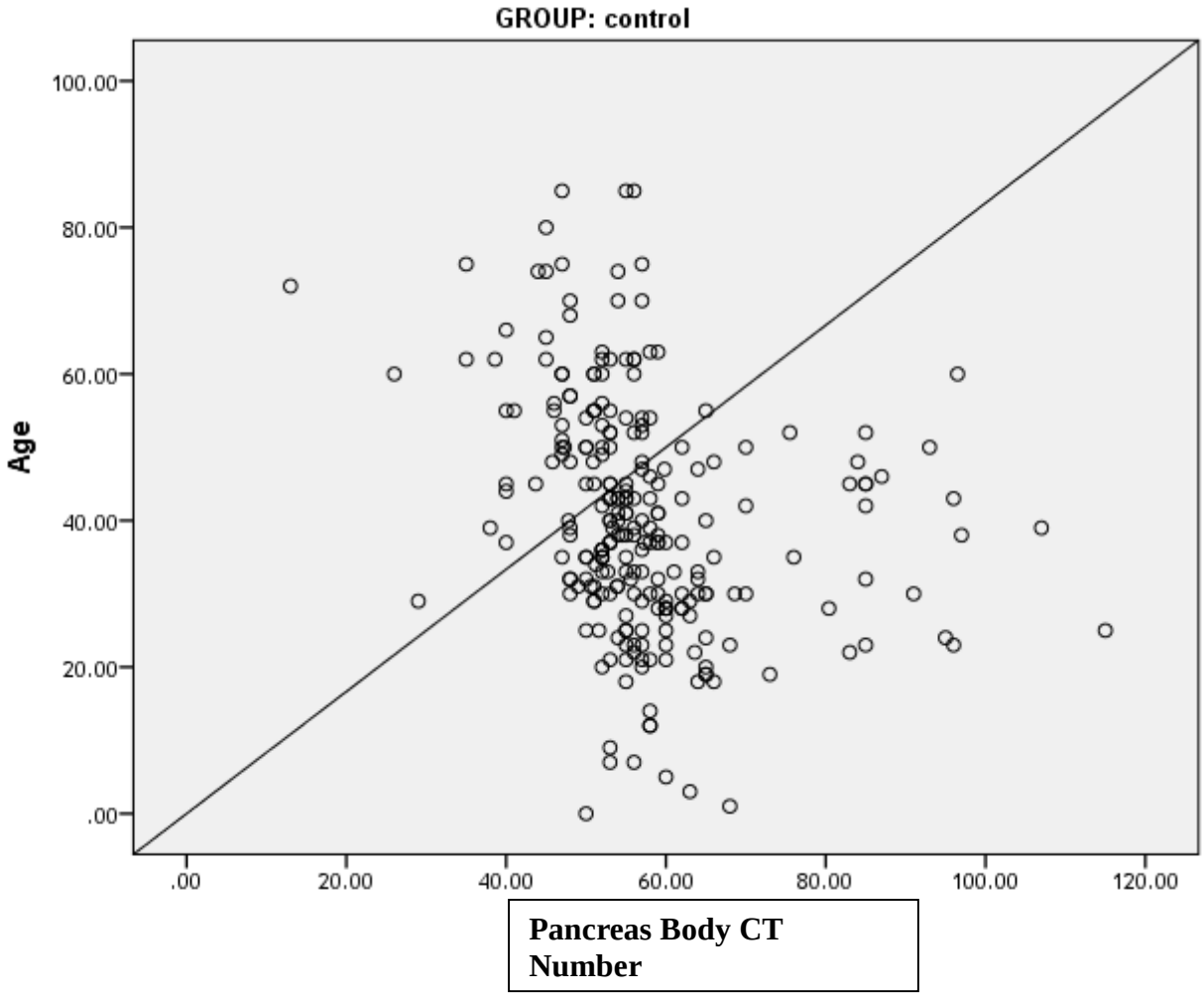

Figure 4.5 A scatter plot diagram shows Linear relationship between the pancreas Body CT number and patient age/ Years for the control group, The Contribution of age on the CT number of Pancreas is2%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=60.823-0.355Xage

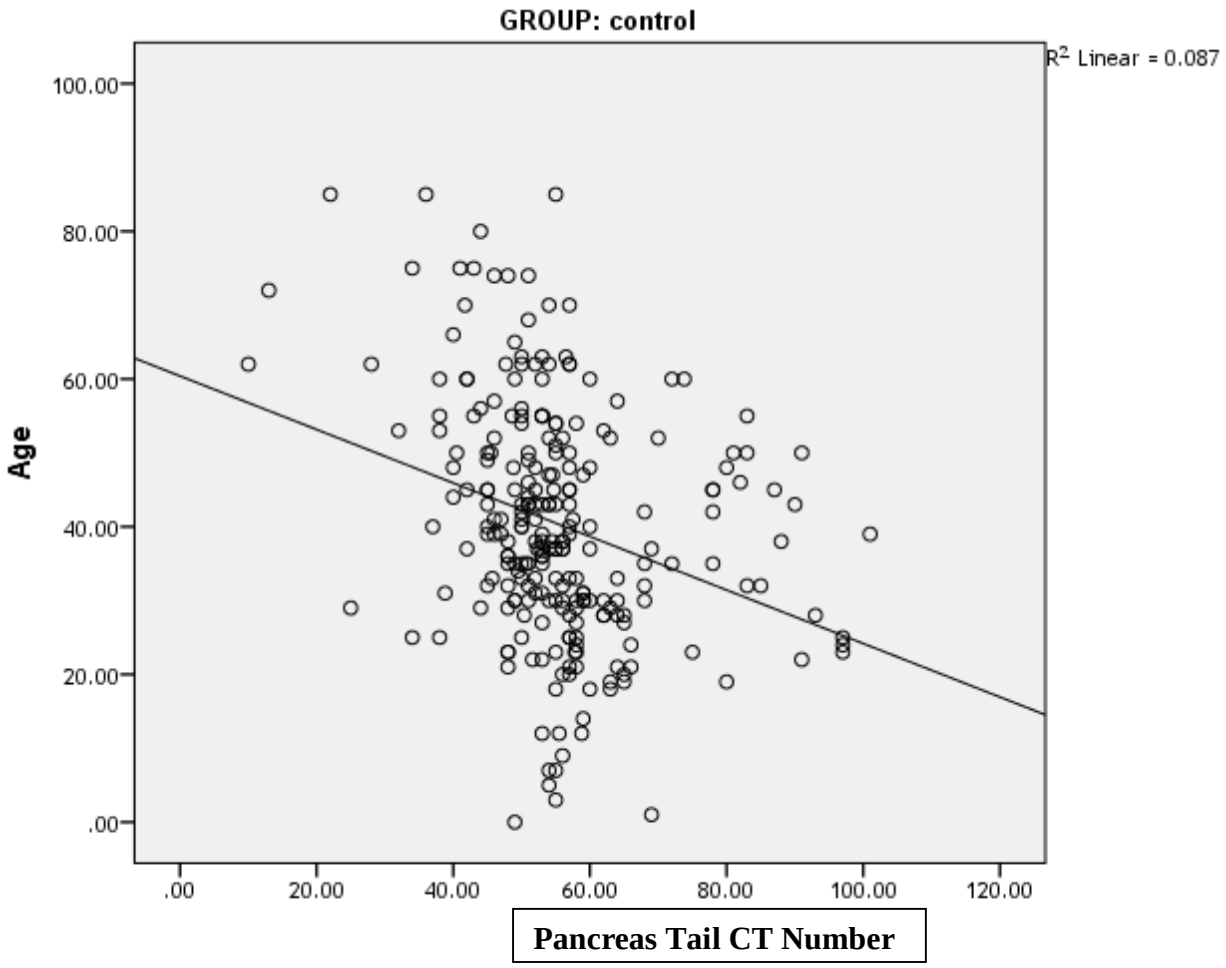

Figure 4.6 A scatter plot diagram shows Linear relationship between the pancreas Tail CT number and patient age/Years for the control group, The Contribution of age on the CT number of Pancreas is8%

Predictive equation of Pancreas Tail CT Number:-

Pancreas Tail CT Number=60.412-0.362Xage

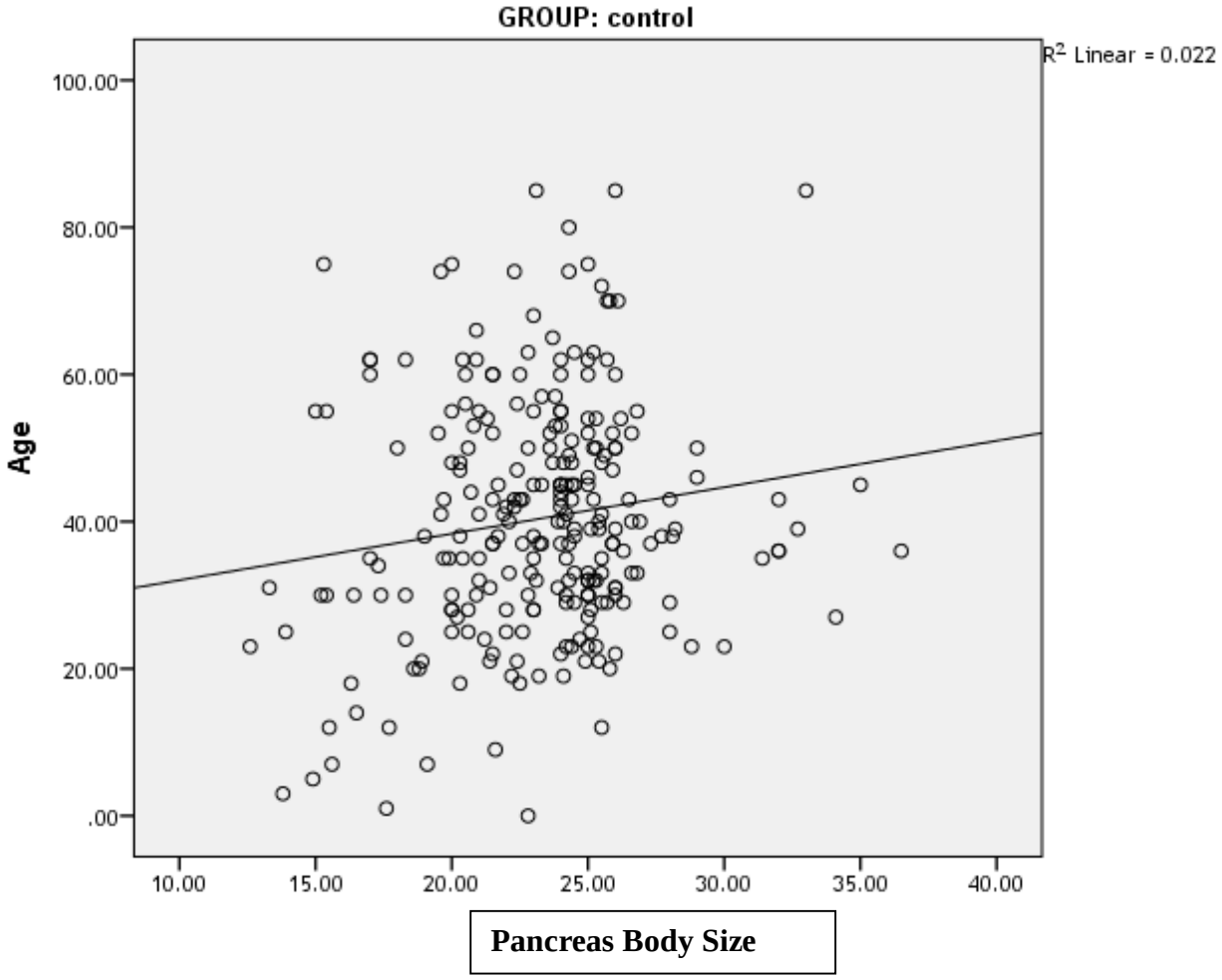

Figure 4.7A scatter plot diagram shows Linear relationship between the pancreas Body Size and patient age/Years for the control group, The Contribution of age to do any change on the Pancreas body sizes is 2%.

Predictive equation of Pancreas Body Size:-

Pancreas Body Size=25.723+0.632Xage

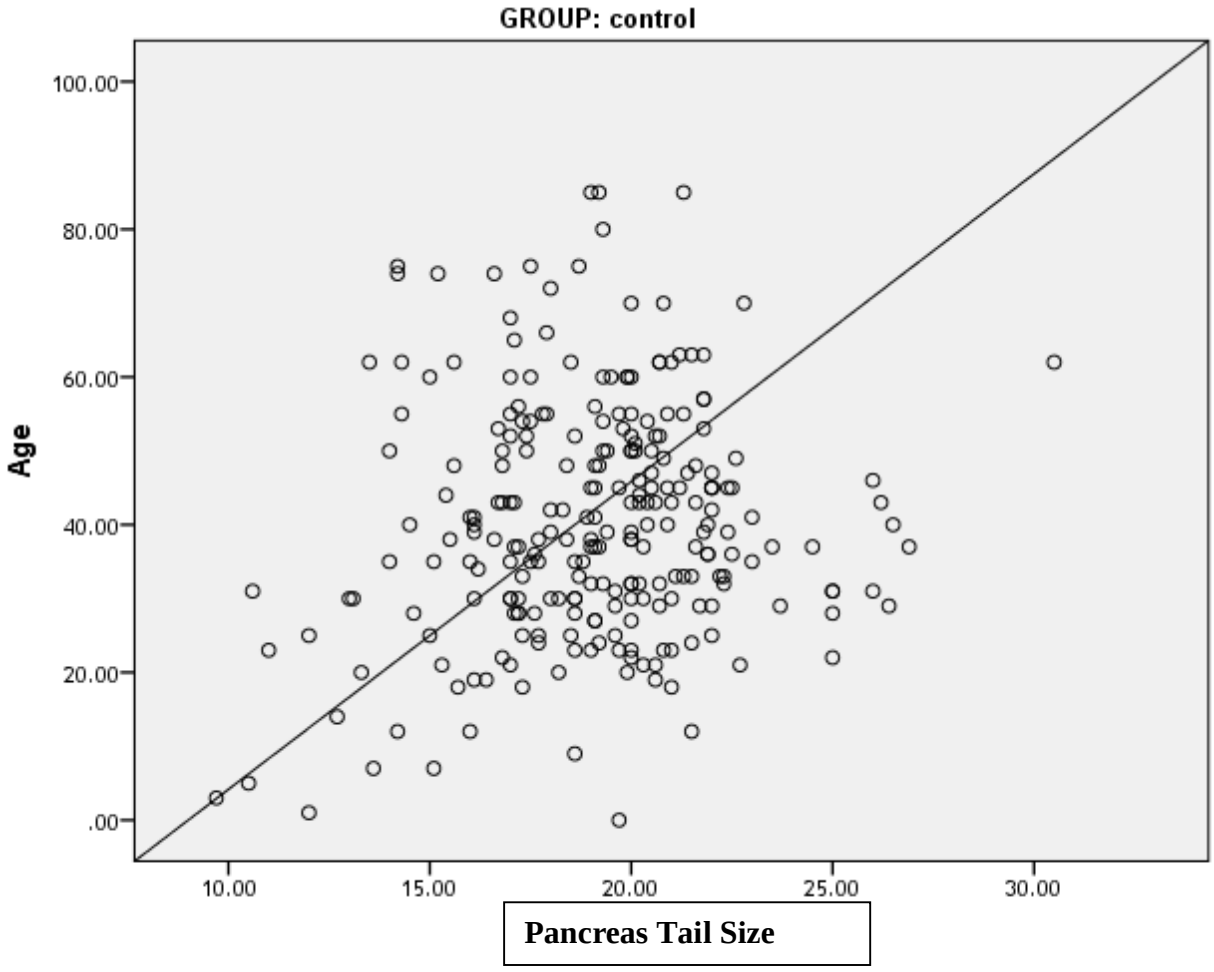

Figure 4.8 A scatter plot diagram shows Linear relationship between the pancreas Tail Size and patient age/Years for the control group, The Contribution of age to do change on the Pancreas Tail sizes is 2%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size=27.415+0.680Xage

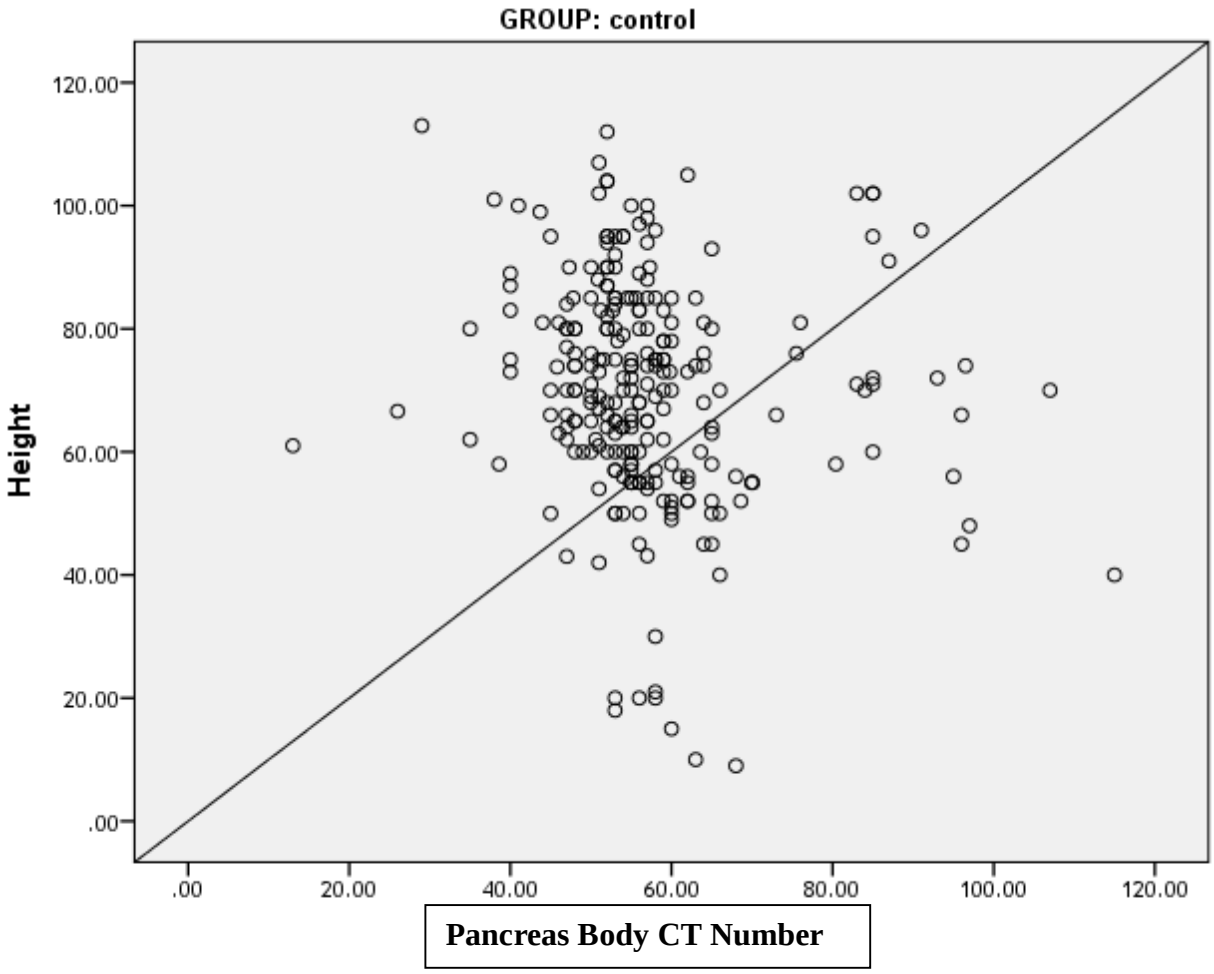

Figure 4.9 A scatter plot diagram shows Linear relationship between the pancreas Body CT Number patient height for the control group, The Contribution of height to do change on the Pancreas body CT number is 2%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=81.615-0.200Xheight

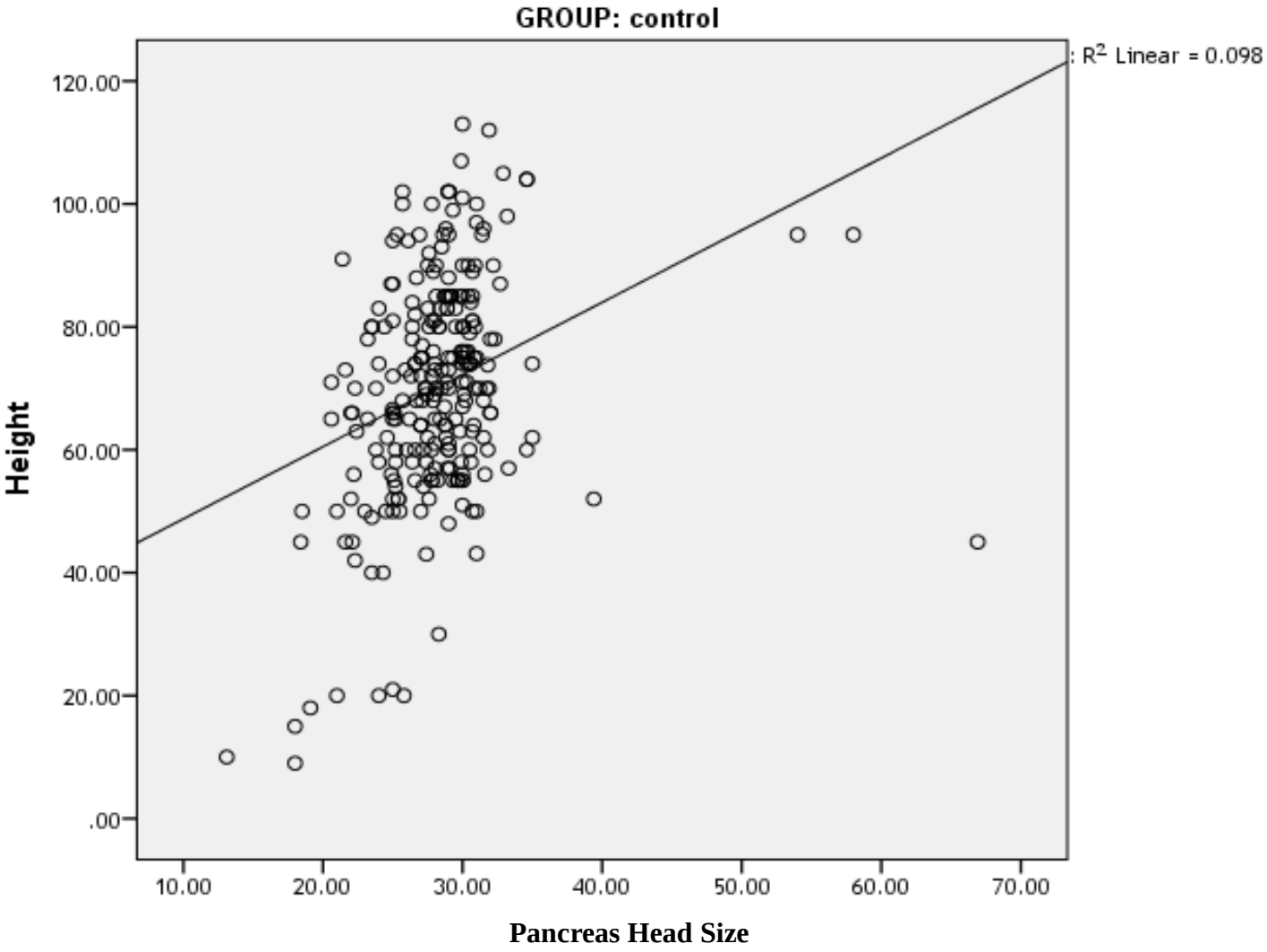

Figure 4.10 A scatter plot diagramme shows Linear relationship between the pancreas Head size and patient Height for the control group, The Contribution of height to do change on the Pancreas Head sizes is 100%.*P*=0.000

Predictive equation of Pancreas Head Size:-

Pancreas Head Size =22.319+0.083XSubject Height

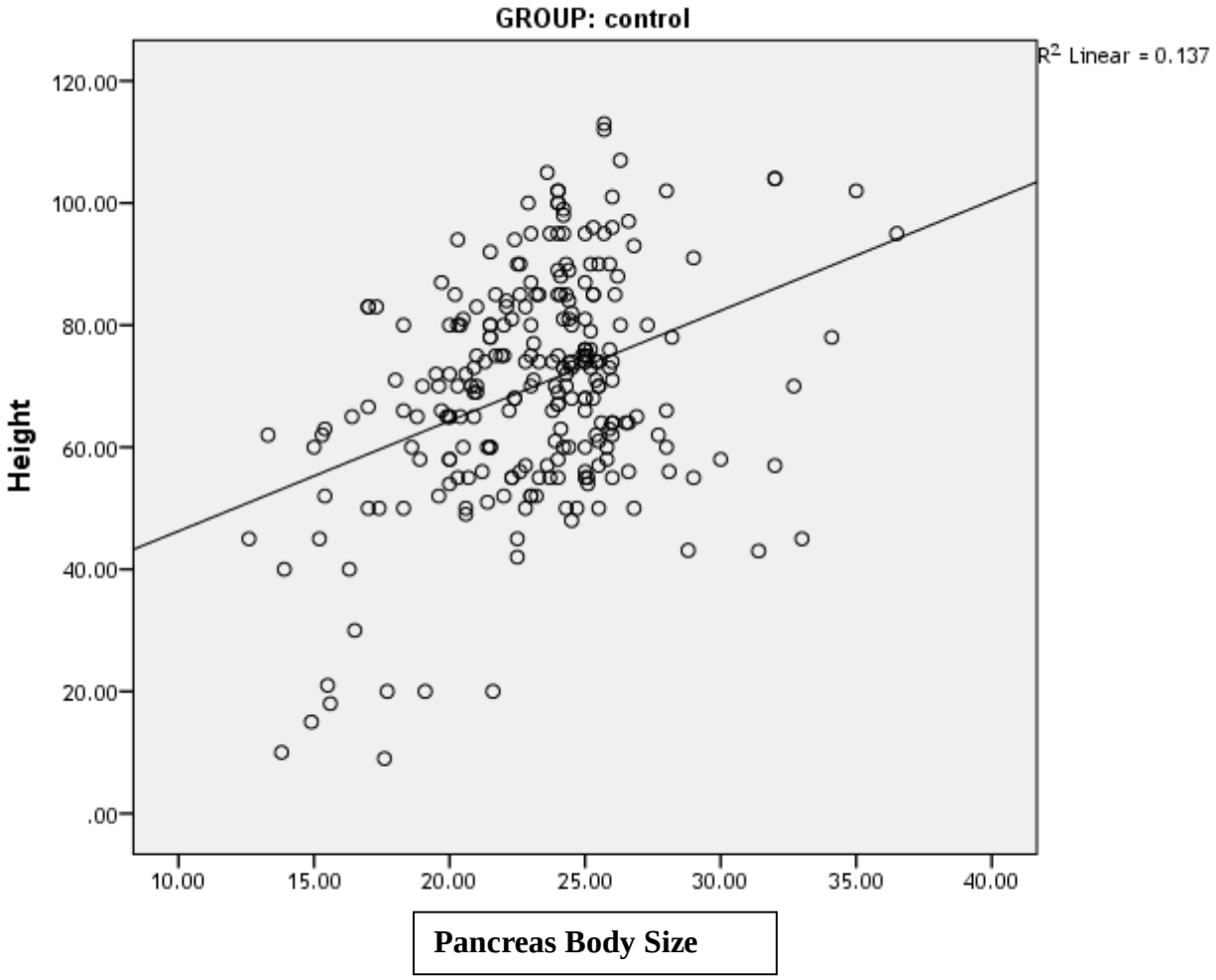

Figure 4.11A scatter plot diagram shows Linear relationship between the pancreas Body size and patient Height for the control group, The Contribution of height to do change on the Pancreas body sizes is 14%

Predictive equation of Pancreas Body Size:-

Pancreas Body Size =28.201+1.806XSubject Height

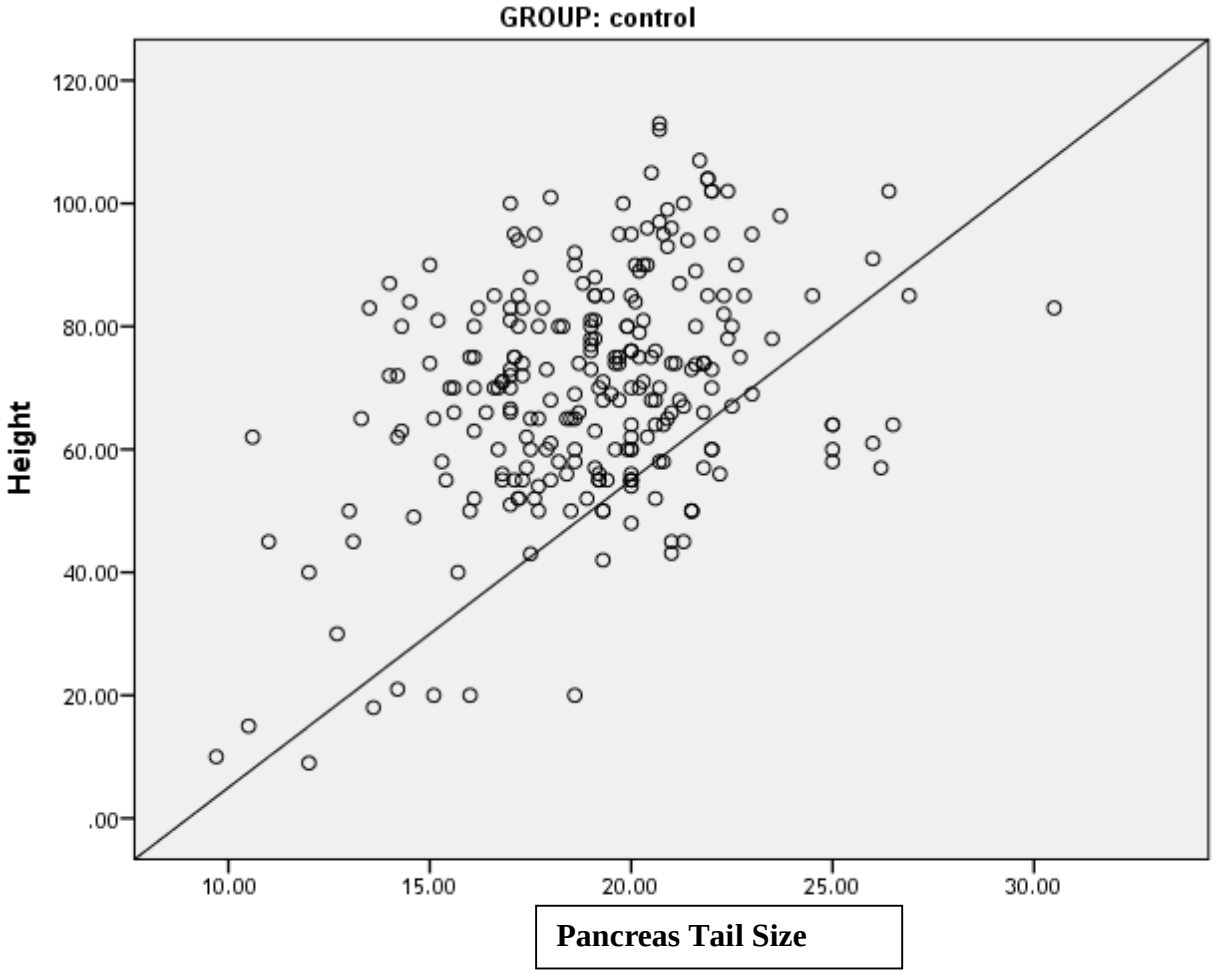

Figure 4.12 A scatter plot diagram shows Linear relationship between the pancreas Tail size and patient Height for the control group, The Contribution of height to do change on the Pancreas Tail sizes is 16%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size =27.00+20262XSubject Height

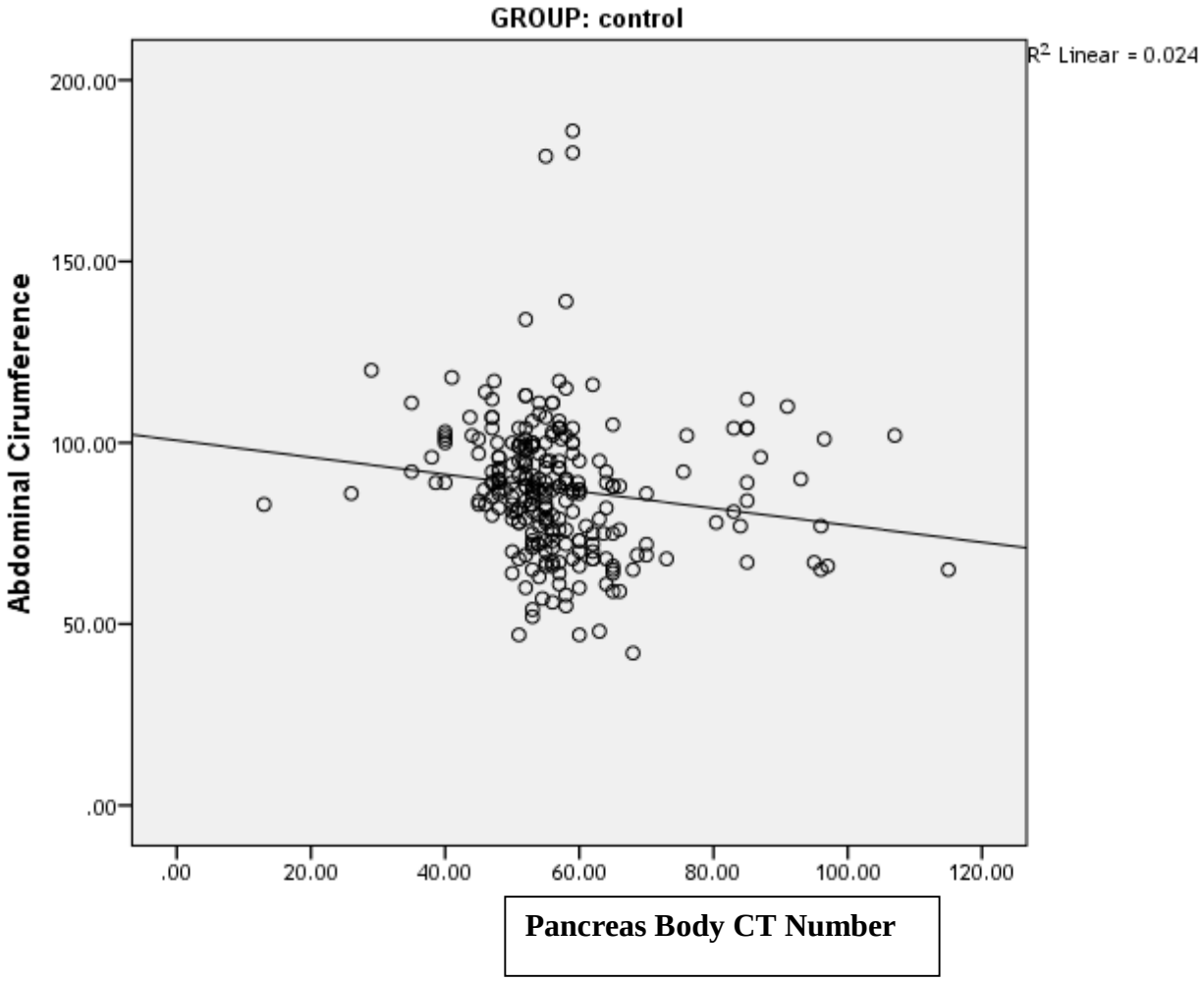

Figure 4.13 A scatter plot diagram shows Linear relationship between the pancreas Body CT number and patient abdominal Circumference for the control group, The Contribution of abdominal Circumference to do change on the Pancreas CT number is 2%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=100.670-0.234Xabdominal circumference

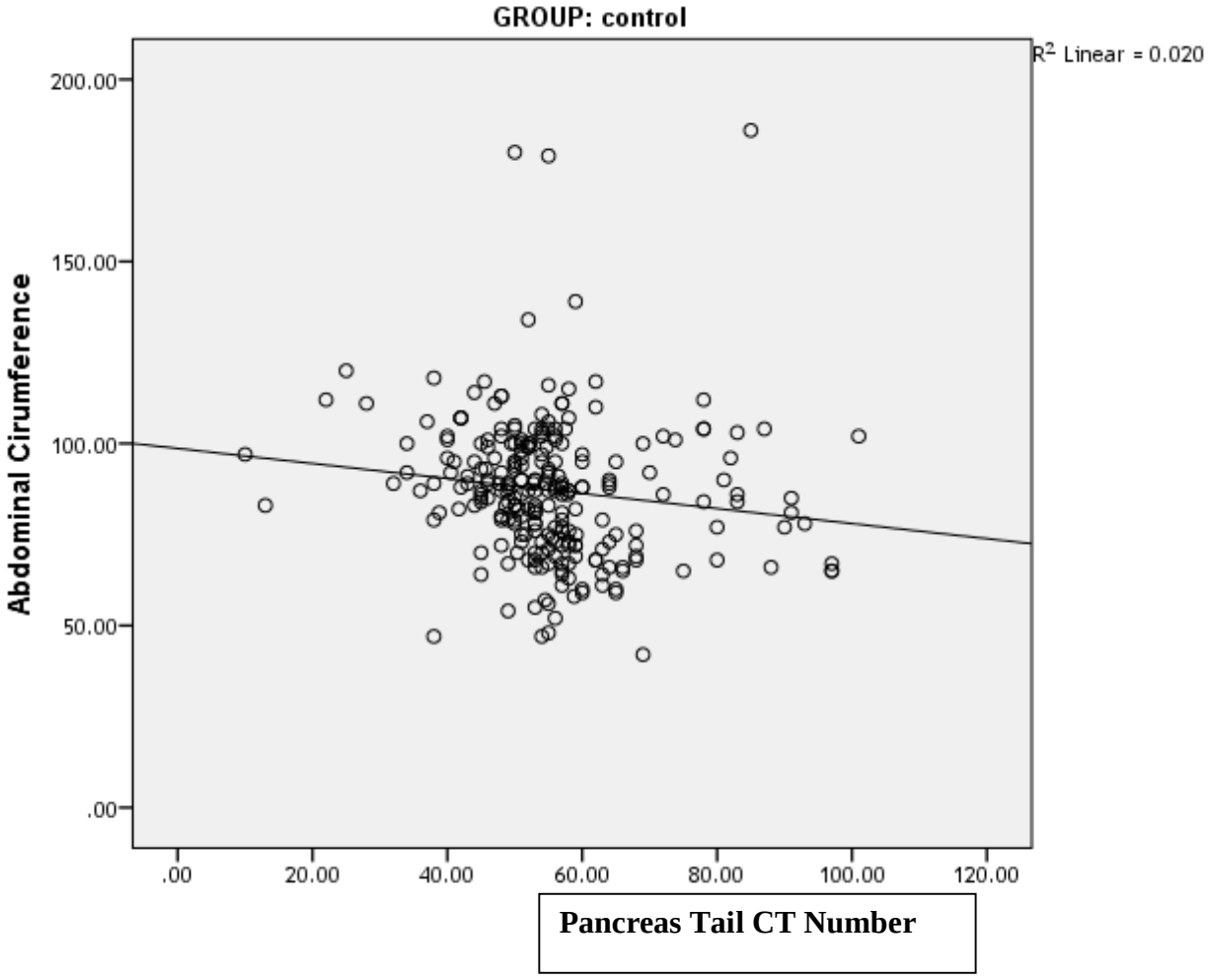

Figure 4.14 A scatter plot diagram shows Linear relationship between the pancreas Tail CT number and patient abdominal Circumference for the control group, The Contribution of abdominal Circumference to do change on the Pancreas CT number is 2%

Predictive equation of Pancreas Tail CT Number:-

Pancreas Tail CT Number=98.650-0.206Xabdominal circumference

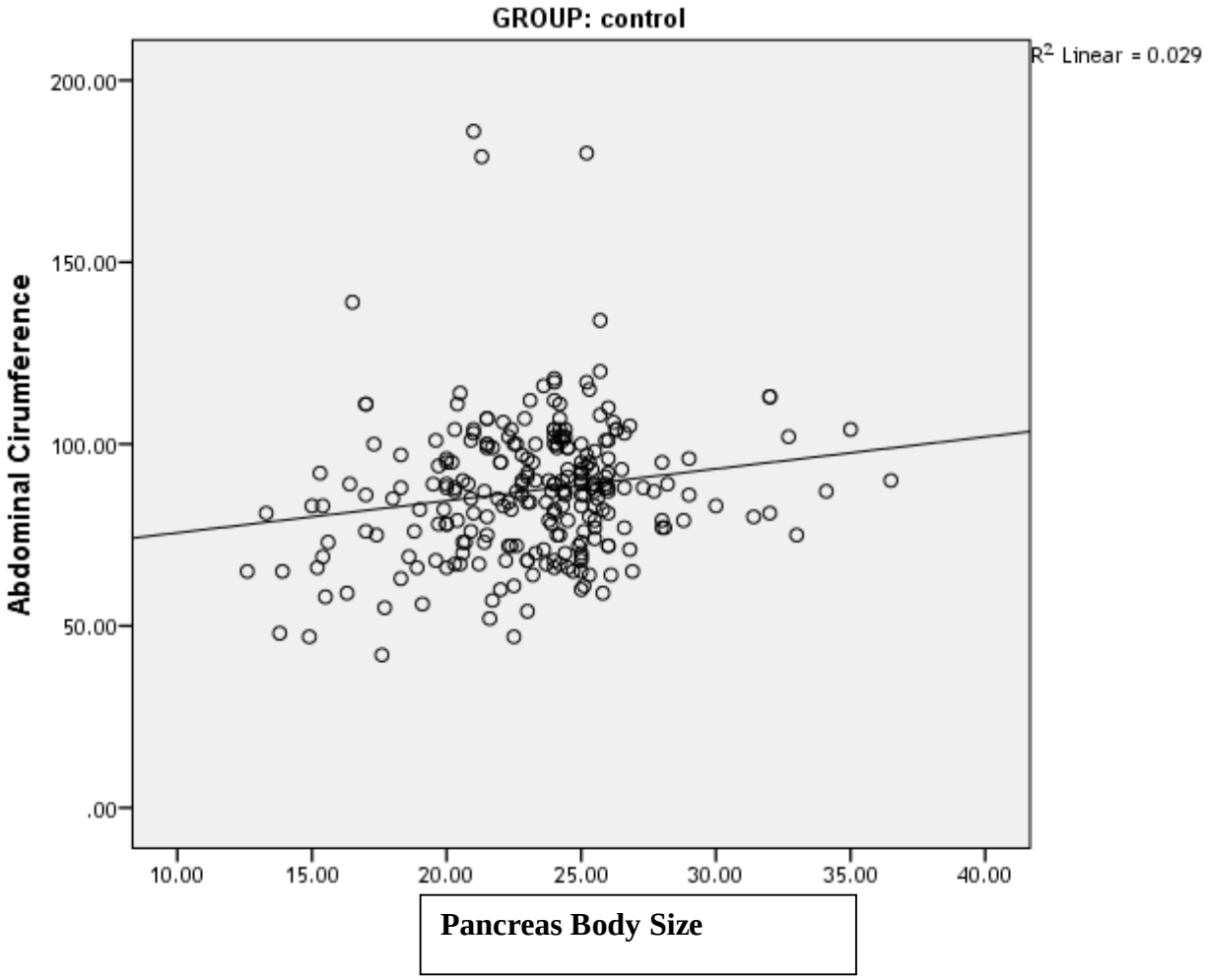

Figure 4.15 A scatter plot diagram shows Linear relationship between the pancreas Body Size and patient abdominal Circumference for the control group, The Contribution of abdominal Circumference to do change on the Pancreas body size is 3%

Predictive equation of Pancreas Body Size:-

Pancreas Body CT Size=66.824+0.879Xabdominal circumference

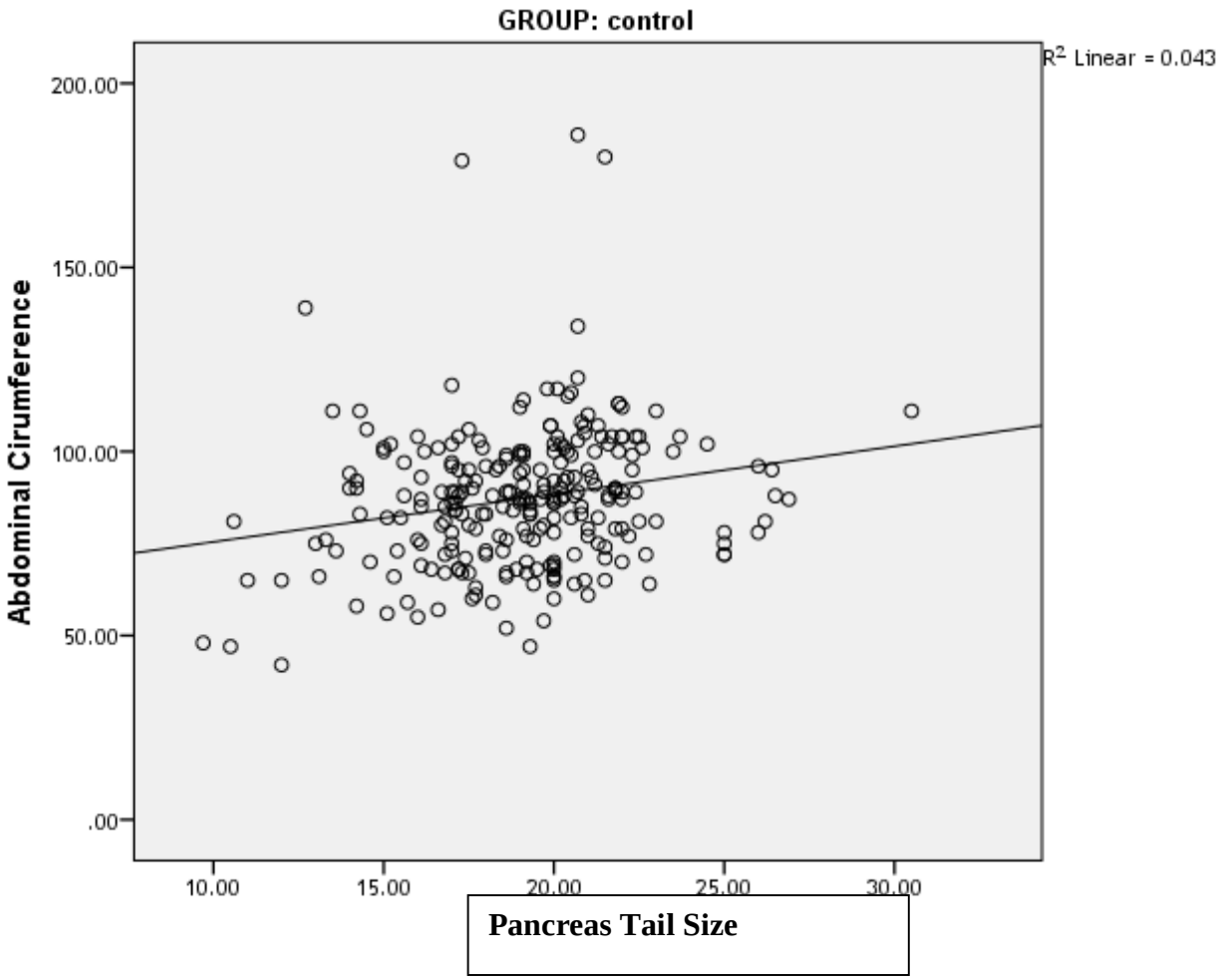

Figure 4.16 A scatter plot diagram shows Linear relationship between the pancreas Tail Size and patient abdominal Circumference for the control group, The Contribution of abdominal Circumference to do change on the Pancreas Tail size is 4%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size=62.456+1.292Xabdominal circumference

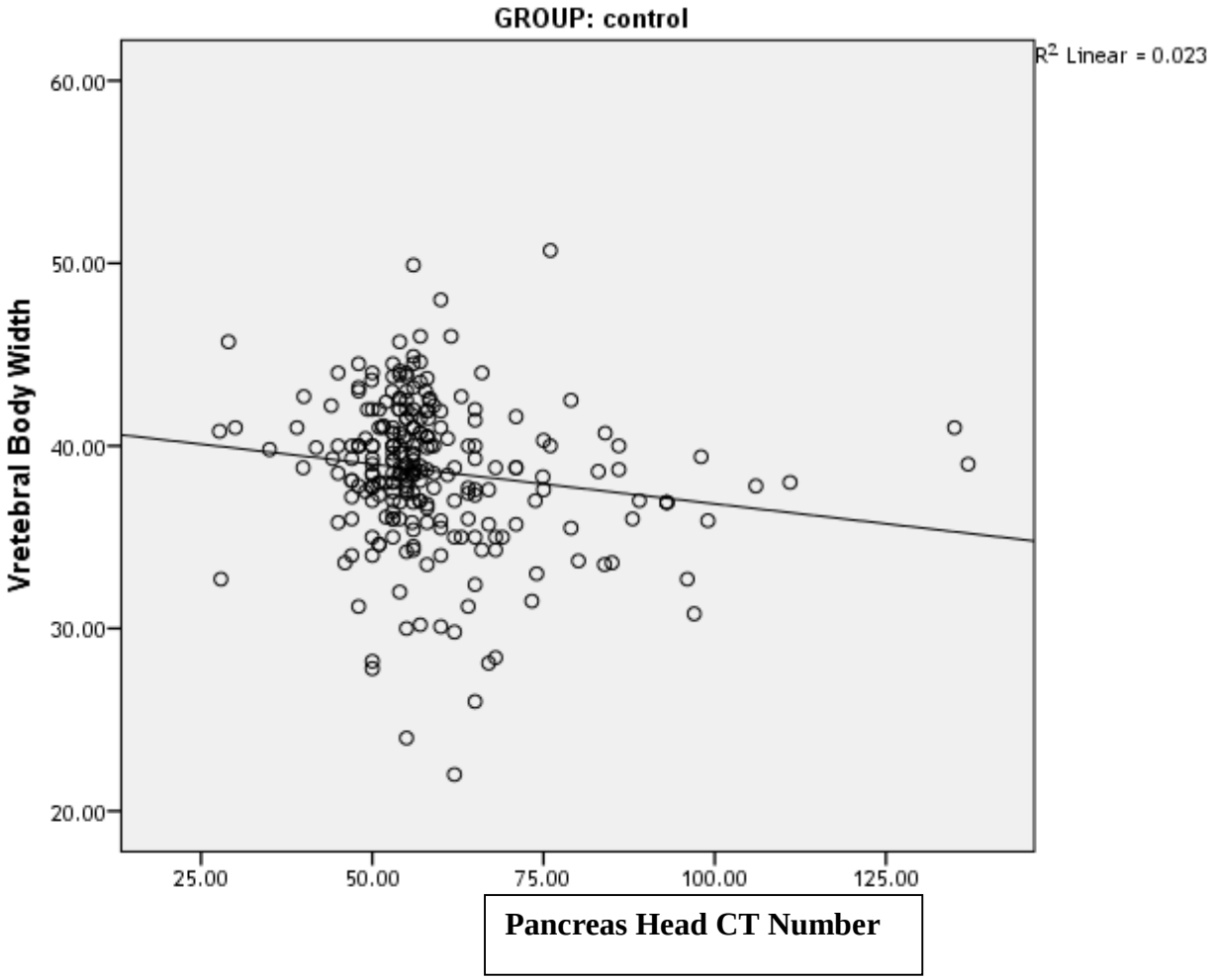

Figure 4.17 A scatter plot diagram shows Linear relationship between the pancreas Head CT Number and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Head CT number is 2%

Predictive equation of Pancreas Head CT Number:-

Pancreas Head CT Number=41.184-0.44Xvertebra Body Width

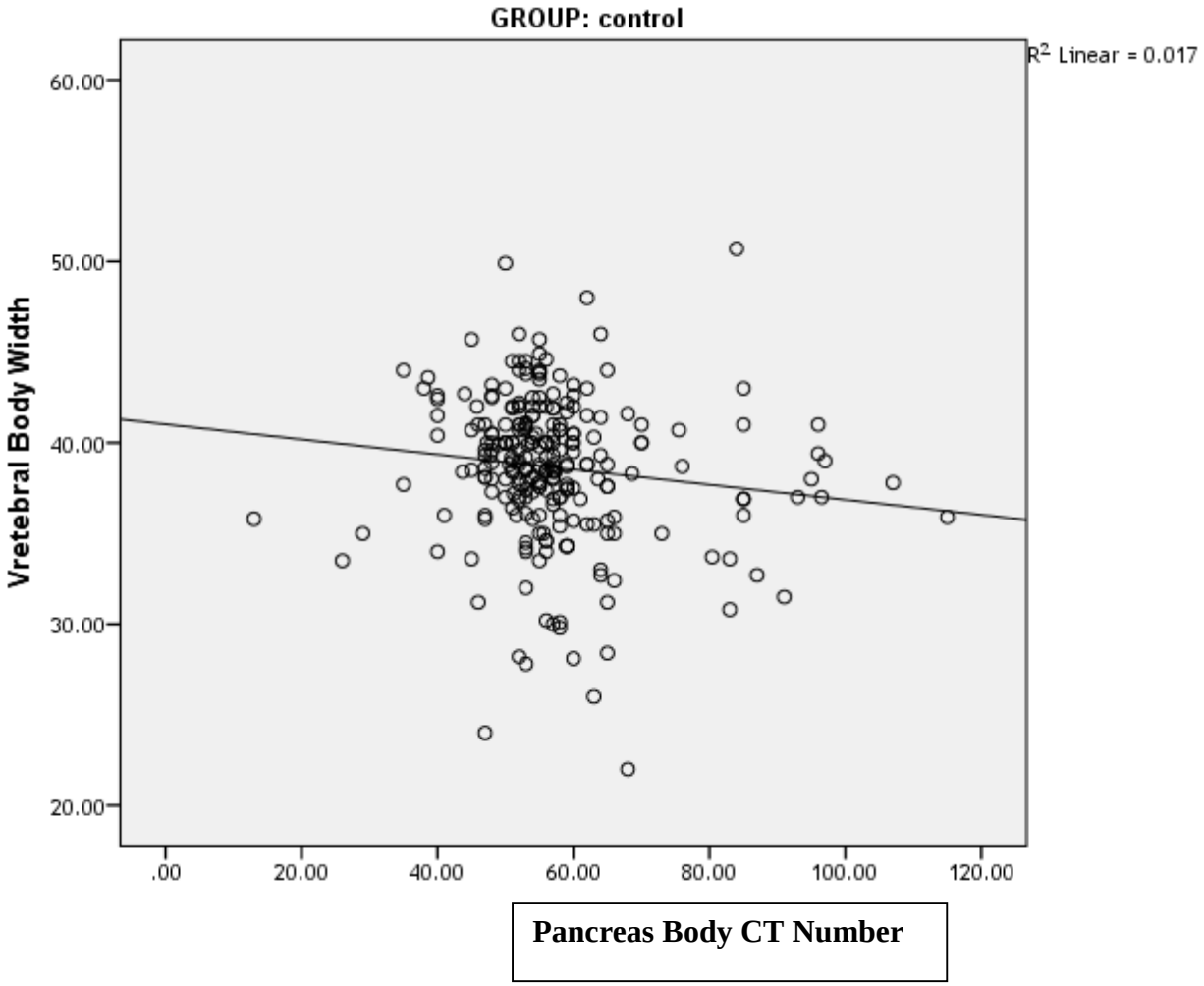

Figure 4.18 A scatter plot diagram shows Linear relationship between the pancreas Body CT Number and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Body CT number is 2%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=41.020-0.042Xvertebra Body Width

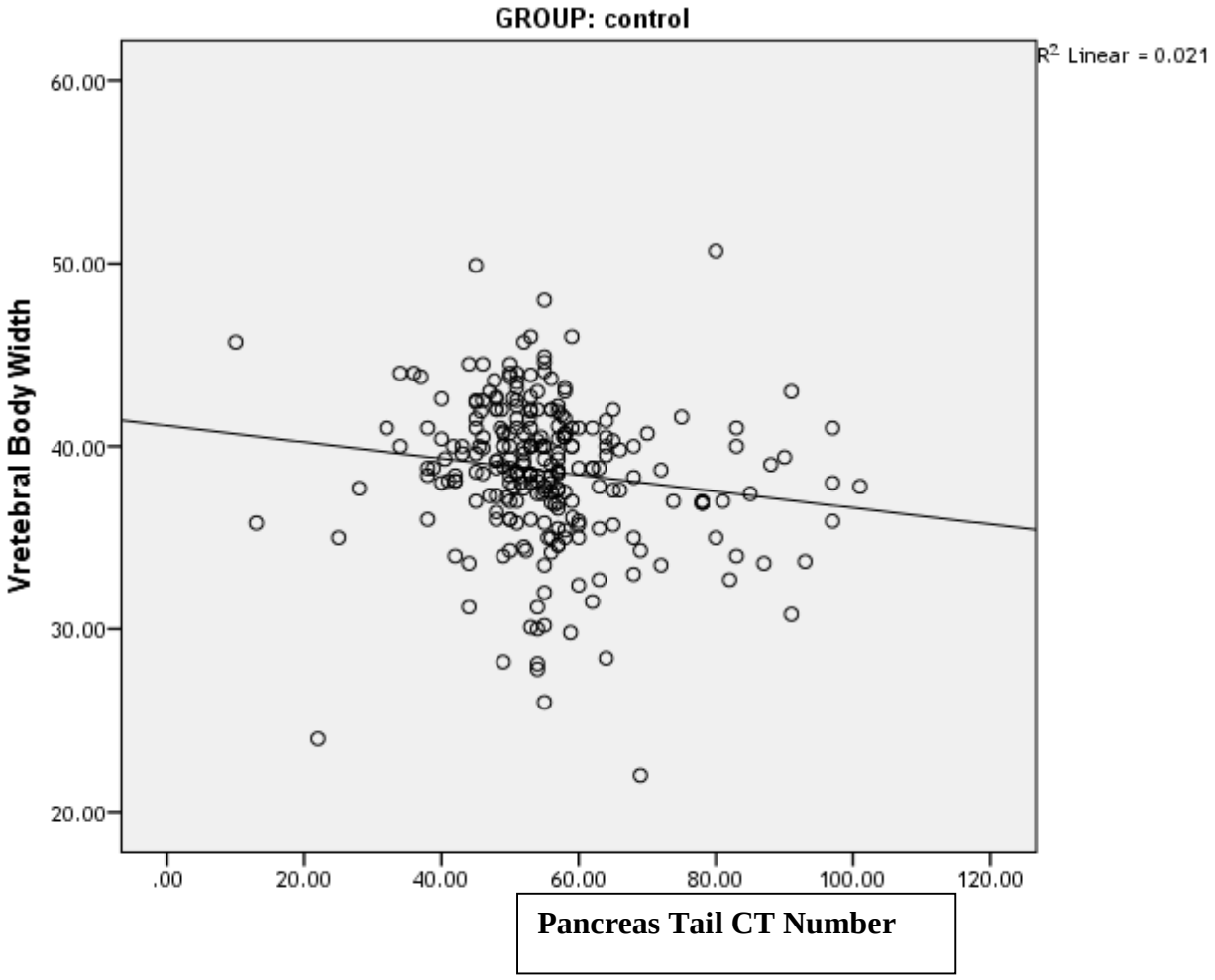

Figure 4.19 A scatter plot diagram shows Linear relationship between the pancreas Tail CT Number and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Tail CT number is 2%

Predictive equation of Pancreas Tail CT Number:-

Pancreas Tail CT Number=41.126-0.045Xvertebra Body Width

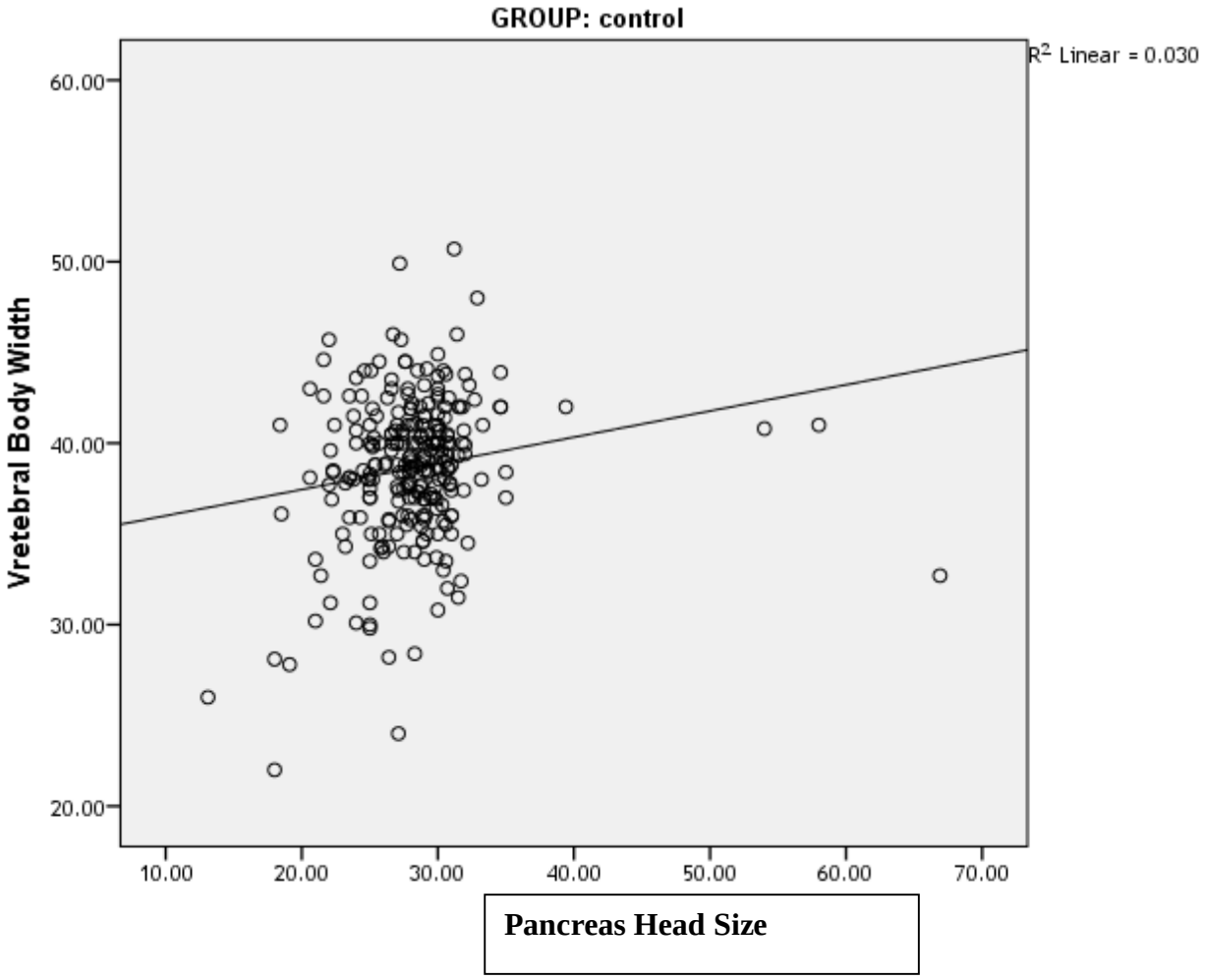

Figure 4.20 A scatter plot diagram shows Linear relationship between the pancreas Head Size and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Head size is 3%

Predictive equation of Pancreas Head Size:-

Pancreas Head Size=34.561+0.144Xvertebra Body Width

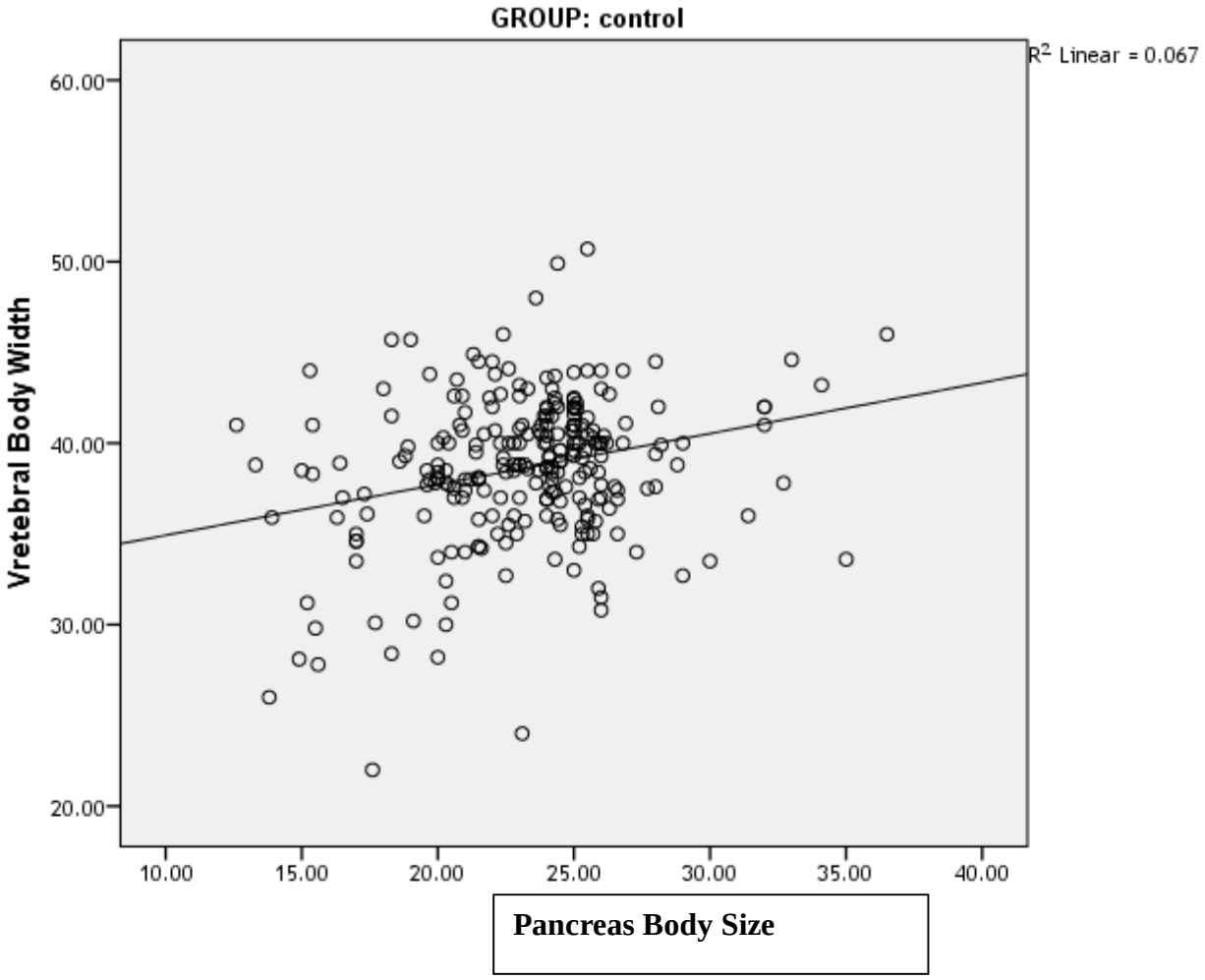

Figure 4.21 A scatter plot diagram shows Linear relationship between the pancreas Body Size and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Body size is 7%

Predictive equation of Pancreas Body Size:-

Pancreas Body Size=32.124+0.280Xvertebra Body Width

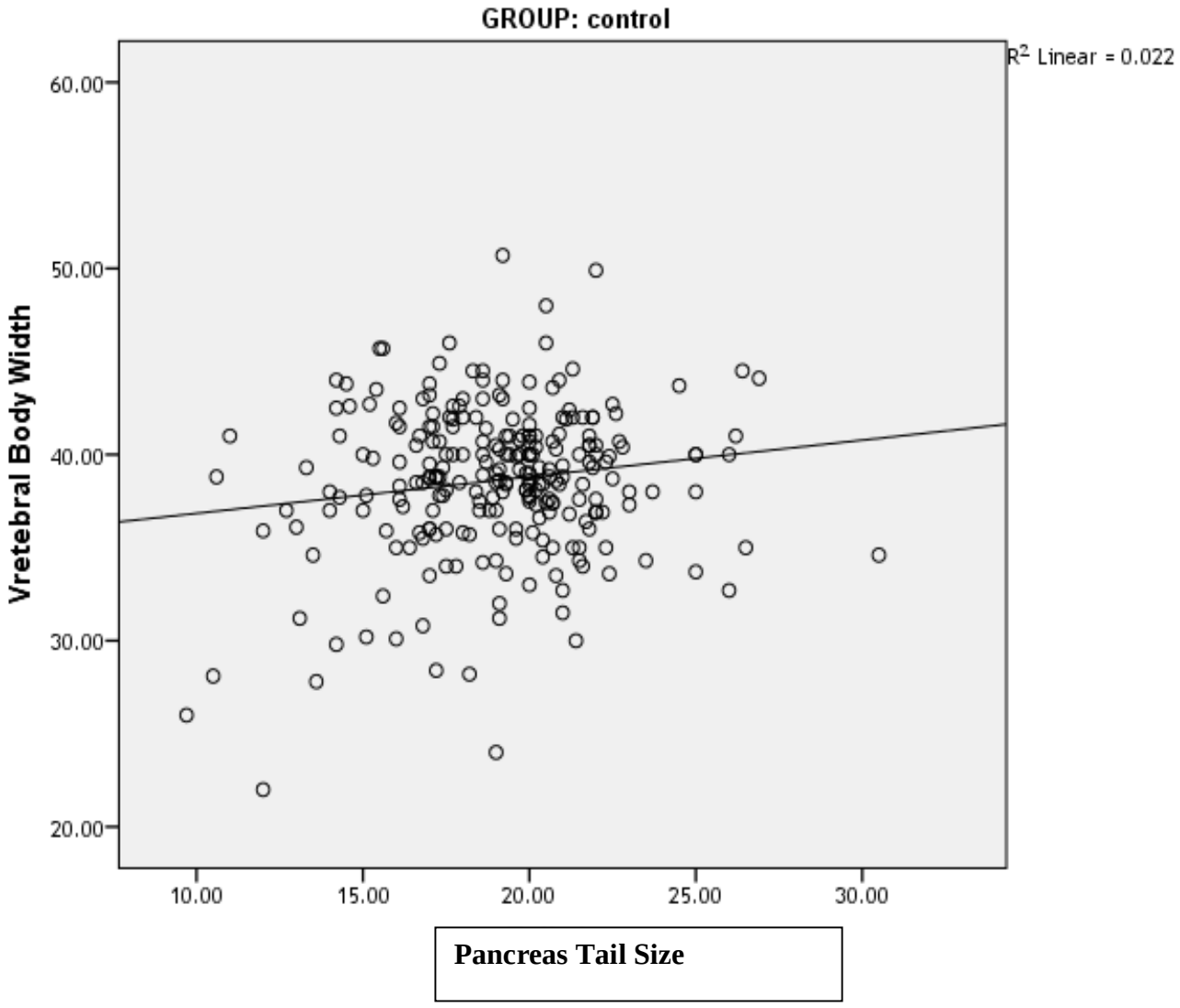

Figure 4.22 A scatter plot diagram shows Linear relationship between the pancreas Tail Size and patient Vertebra Body Width for the control group, The Contribution of Vertebra Body Width to do change on the Pancreas Tail Size is 2%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size=14.713+0.112Xvertebra Body Width

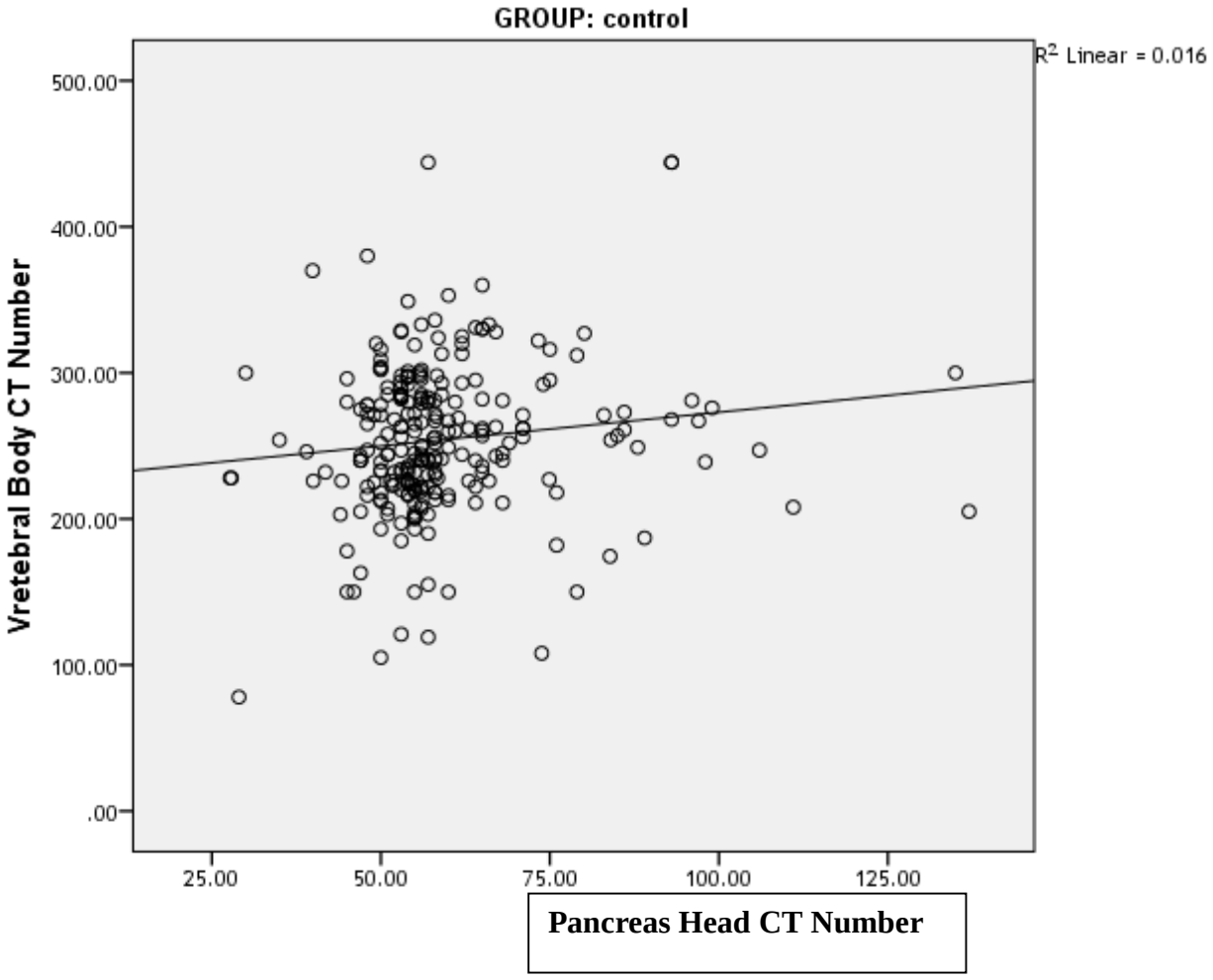

Figure 4.23 A scatter plot diagram shows Linear relationship between the pancreas Head CT Number and patient Vertebra Body CT Number for the control group, The Contribution of Vertebra Body CT Number to do change on the Pancreas Head CT number is 2%

Predictive equation of Pancreas Head CT Number:-

Pancreas Head CT Number=226.925+0.461Xvertebra Body CT Number

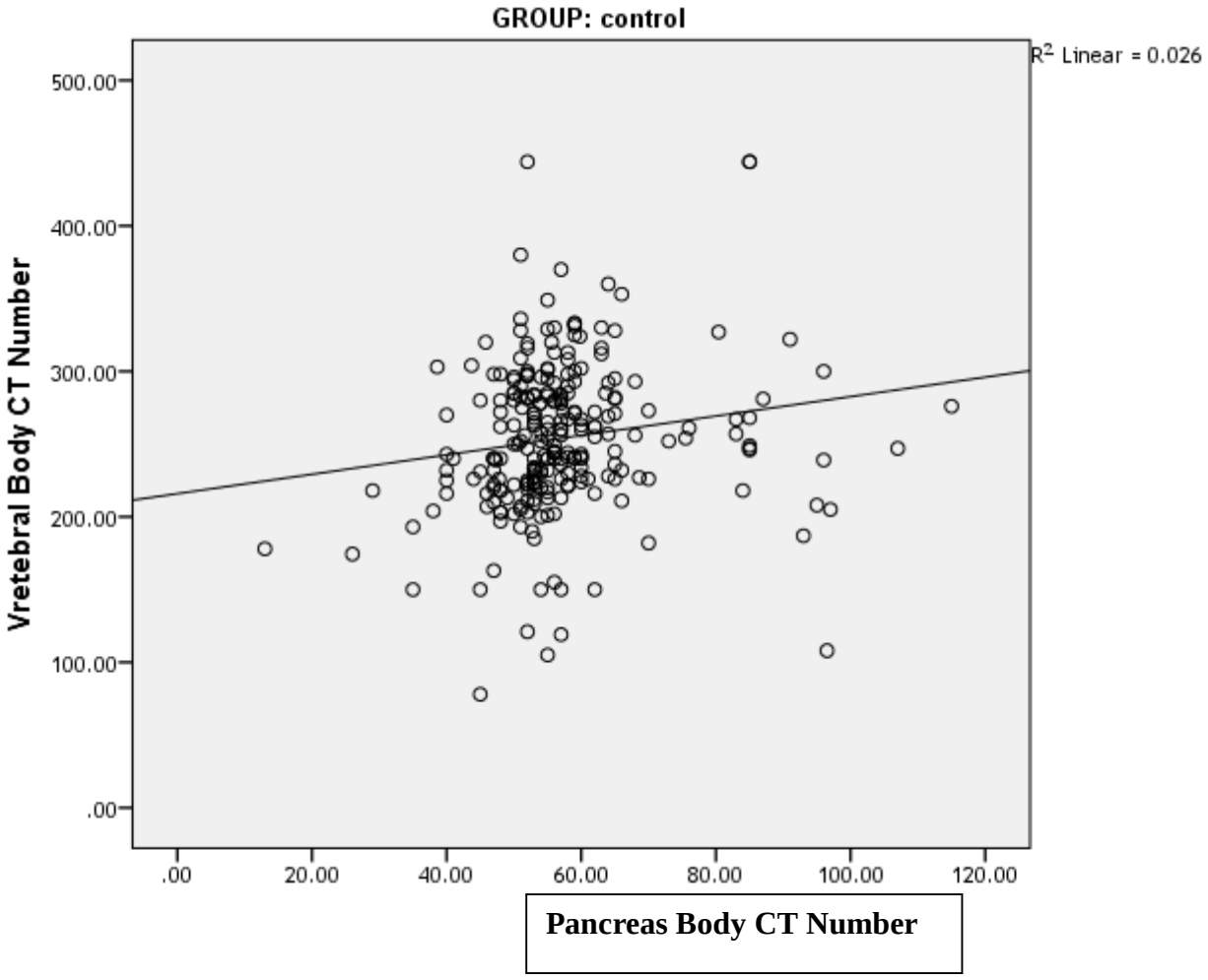

Figure 4.24 A scatter plot diagram shows Linear relationship between the pancreas Body CT Number and patient Vertebra Body CT Number for the control group, The Contribution of Vertebra Body CT Number to do change on the Pancreas Body CT Number is 3%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=215.93+0.667Xvertebra Body CT Number

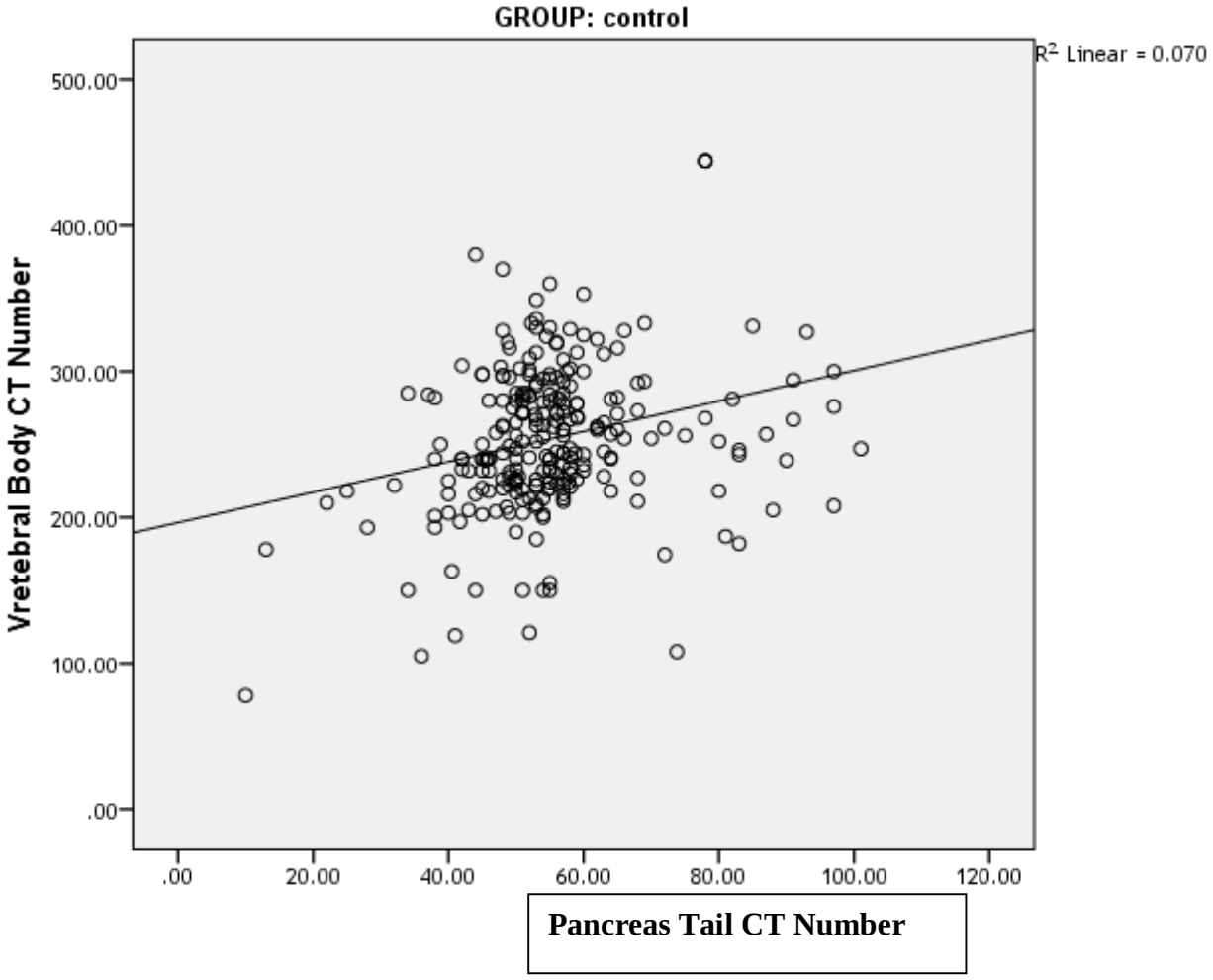

Figure 4.25 A scatter plot diagram shows Linear relationship between the pancreas Tail CT Number and patient Vertebra Body CT Number for the control group, The Contribution of Vertebra Body CT Number to do change on the Pancreas Tail CT Number is 1%

Predictive equation of Pancreas Tail CT Number:-

Pancreas Tail CT Number=196.446+1.041Xvertebra Body CT Number

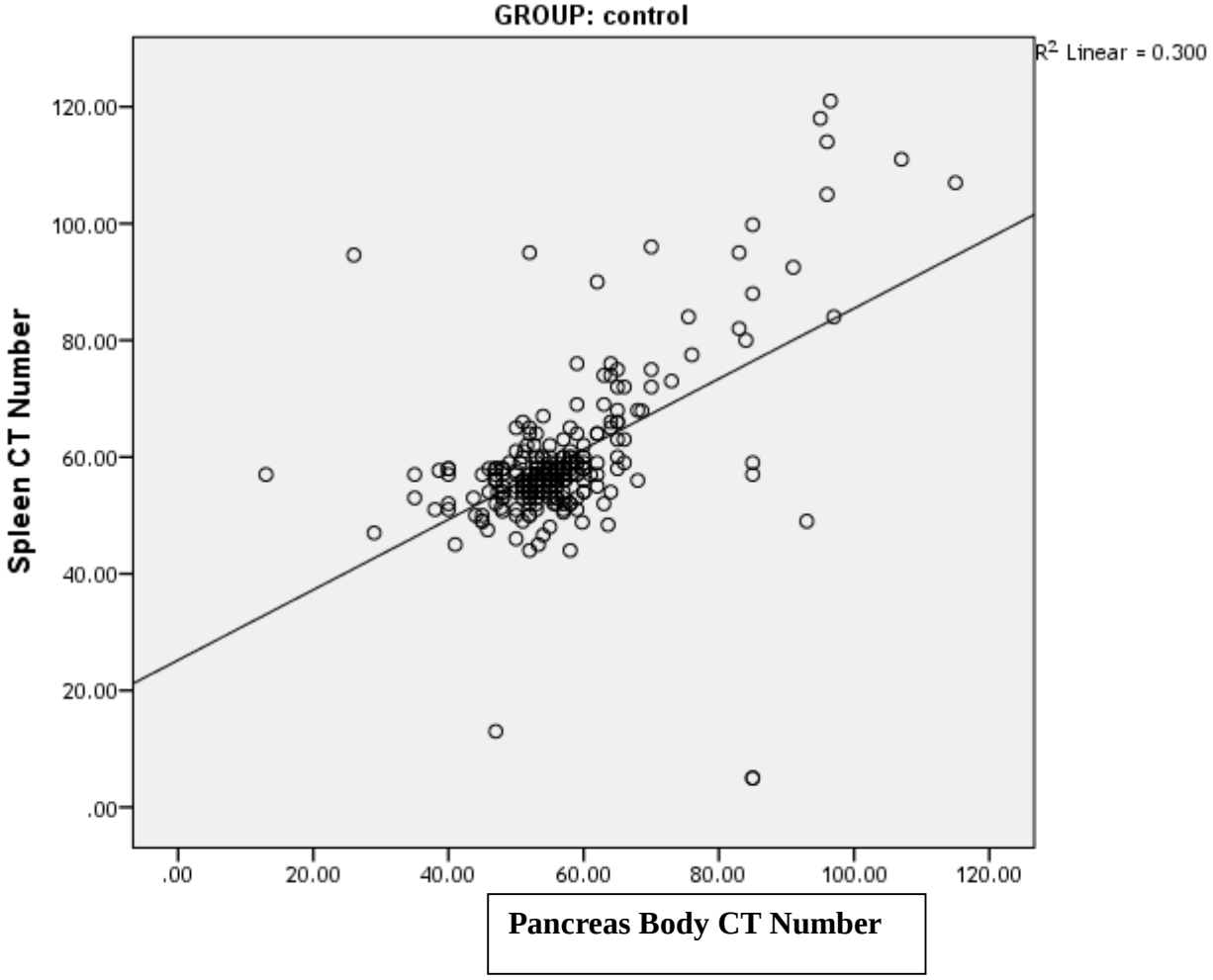

Figure 4.26 A scatter plot diagram shows Linear relationship between the pancreas Body CT Number and patient Spleen CT Number for the control group, The Contribution of Spleen CT Number to do change on the Pancreas Body CT Number is 30%

Predictive equation of Pancreas Body CT Number:-

Pancreas Body CT Number=25.199+0.603X Spleen CT Number

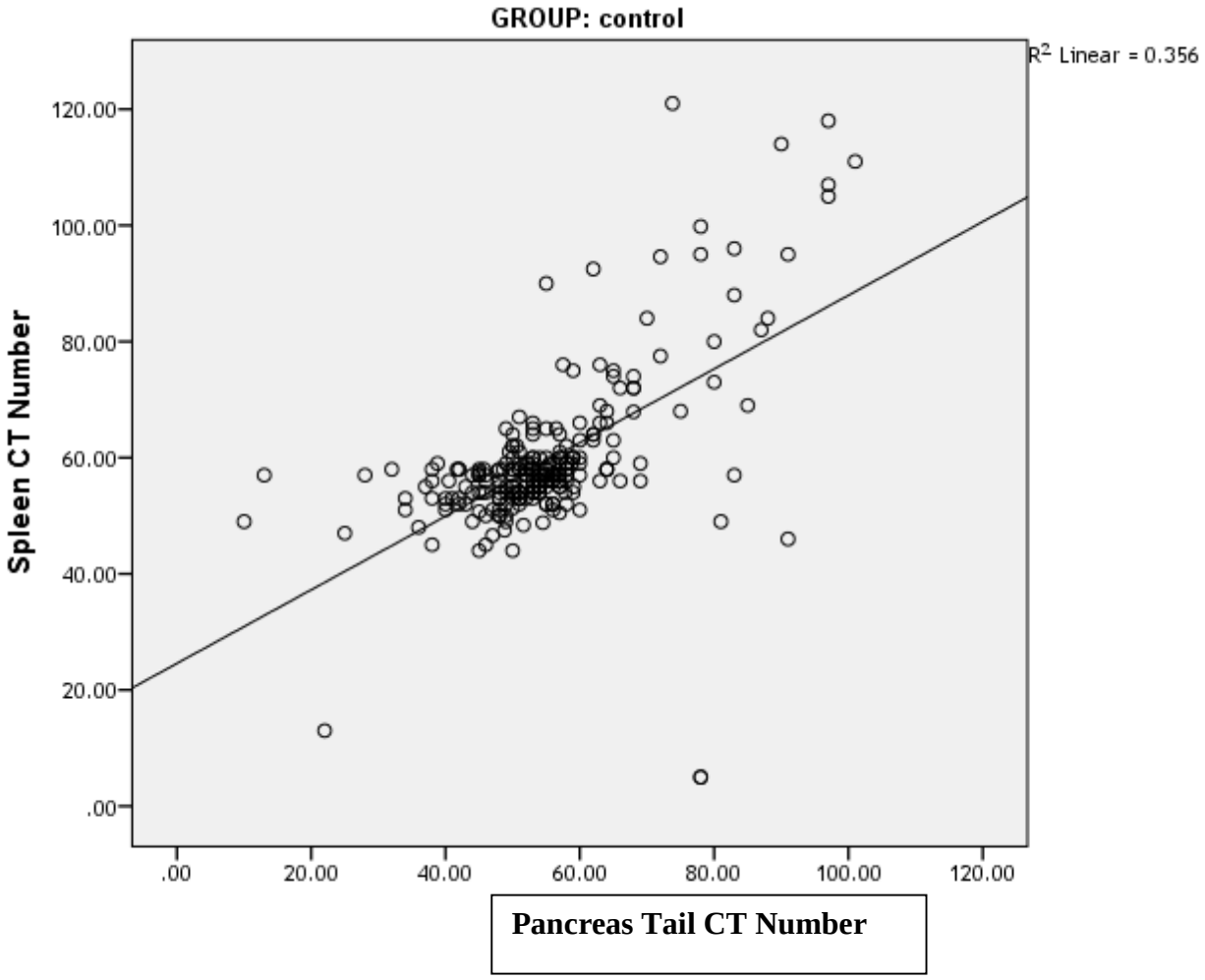

Figure 4.27 A scatter plot diagram shows Linear relationship between the pancreas Tail CT Number and patient Spleen CT Number for the control group, The Contribution of Spleen CT Number to do change on the Pancreas Tail CT Number is 36%

Predictive equation of Pancreas Tail CT Number:-

Pancreas Tail CT Number=24.581+0.634X Spleen CT Number

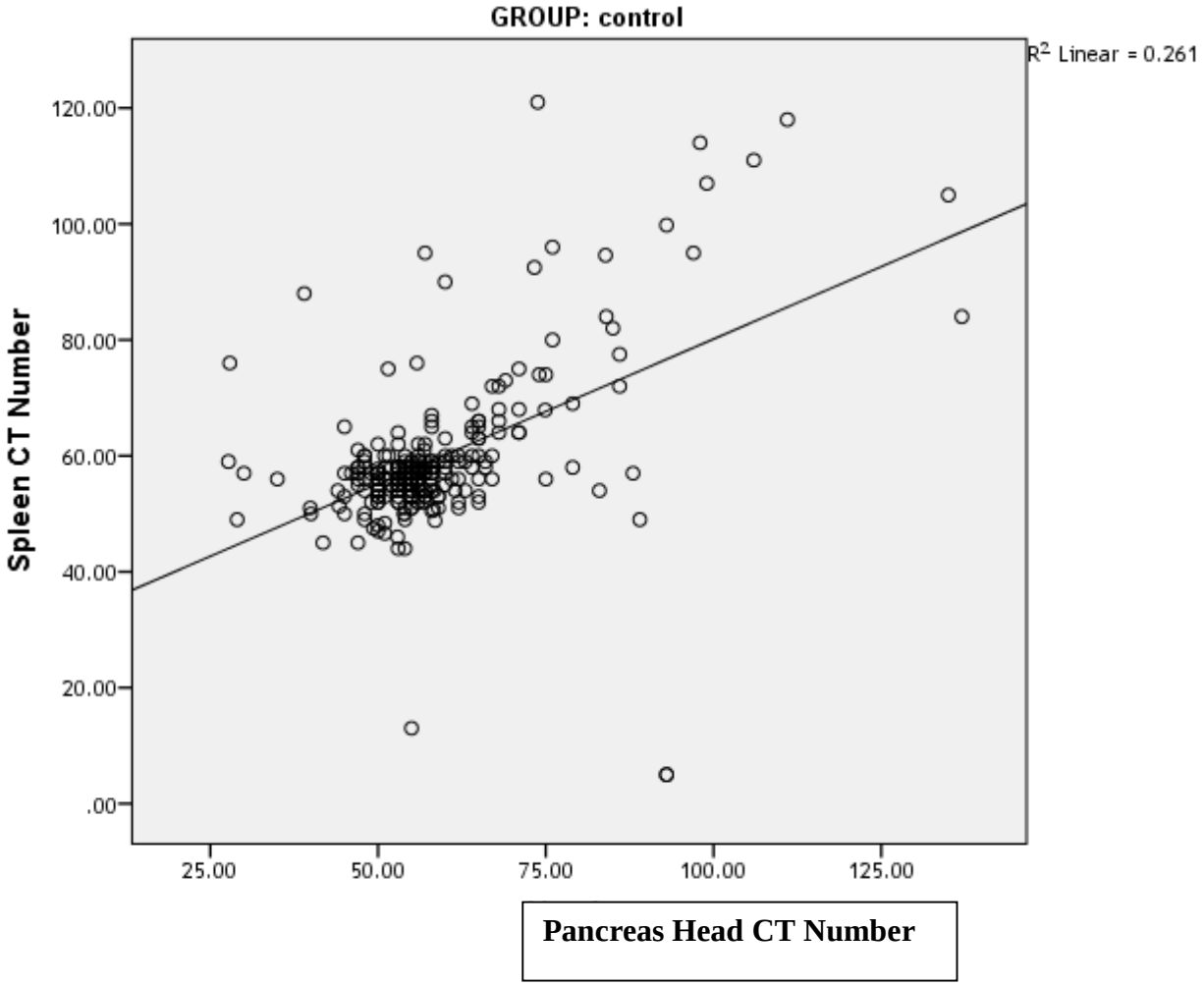

Figure 4.28 A scatter plot diagram shows Linear relationship between the pancreas Head CT Number and patient Spleen CT Number for the control group, The Contribution of Spleen CT Number to do change on the Pancreas Head CT Number is 26%

Predictive equation of Pancreas Head CT Number:-

Pancreas Head CT Number=30.173+0.500X Spleen CT Number

Table (4.10) Correlations between the Pancreas Characteristics and Body characteristics for the Diabetic patients (Group B)

		Head CT Number	***Body CT Number***	***Tail CT Number***	***Head size***	***Body size***	***Tail size***
Age/years	Pearson Correlation	-.140	-.171	-.046	-.094	-.107	.096
	Sig. (2-tailed)	.454	.359	.808	.614	.565	.606
	N	31	31	31	31	31	31
Gender	Pearson Correlation	-.101	-.117	-.091	-.176	-.299	-.258
	Sig. (2-tailed)	.589	.532	.627	.344	.102	.161
	N	31	31	31	31	31	31
Weight/Kg	Pearson Correlation	.003	-.062	-.135	.215	.311	.260
	Sig. (2-tailed)	.987	.739	.470	.246	.088	.159
	N	31	31	31	31	31	31
Height/meter	Pearson Correlation	.246	.243	.254	.524(**)	.122	.271
	Sig. (2-tailed)	.182	.189	.168	.002	.013	.041
	N	31	31	31	31	31	31
Abdominal Circumference (AC)	Pearson Correlation	.035	.146	.041	.125	.151	.036
	Sig. (2-tailed)	.853	.433	.826	.503	.417	.848
	N	31	31	31	31	31	31
Body mass index(BMI)	Pearson Correlation	-.161	-.203	-.270	-.157	.149	.013
	Sig. (2-tailed)	.387	.273	.141	.400	.423	.943
	N	31	31	31	31	31	31
Vertebral Body Width	Pearson Correlation	-.004	.026	.030	.022	.213	.452(*)
	Sig. (2-tailed)	.984	.889	.871	.008	.051	.011
	N	31	31	31	31	31	31
Vertebral Body CT Number	Pearson Correlation	.098	.122	.137	-.045	.038	-.209
	Sig. (2-tailed)	.601	.513	.463	.810	.839	.258
	N	31	31	31	31	31	31

Spleen CT Number	Pearson Correlation	.762(**)	.758(**)	.699(**)	.300	-.029	.075
	Sig. (2-tailed)	.000	.000	.000	.101	.876	.688
	N	31	31	31	31	31	31
Diabetic Duration/yrs	Pearson Correlation	-.063	-.066	-.066	-.240	-.462(**)	-.518(**)
	Sig. (2-tailed)	.738	.725	.725	.015	.009	.003
	N	31	31	31	31	31	31

** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed).

Table (4.11)Independent Samples Test between the Pancreas Head Characteristics (CT Number and size) in both Normal Control Group (Group A) and the Diabetic patients (Group B)

		Levene's Test For Equality Of Variances		***T-Test For Equality Of Means***						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pancrease Head CT Number	Equal variances assumed	.015	.002	-2.18	279	.030	-5.85	2.67	-11.13	-.58
	Equal variances not assumed			-2.31	39.17	.026	-5.85	2.52	-10.96	-.74
Pancrease Head size	Equal variances assumed	21.24	.000	2.11	281	.035	5.92	2.80	.41	11.44
	Equal variances not assumed			0.77	30.09	.447	5.92	7.68	-9.76	21.62

Table (4.12)Independent Samples Test between the Pancreas Body Characteristics (CT Number and size) in both Normal Control Group (Group A) and the Diabetic patients (Group B)

		Levene's Test For Equality Of Variances		***T-Test For Equality Of Means***						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pancrease Body CT Number	Equal variances assumed	1.99	.059	-3.30	280	.001	-8.03	2.42	-12.80	-3.25
	Equal variances not assumed			-3.050	36.27	.004	-8.03	2.63	-13.36	-2.69
Pancrease Body size	Equal variances assumed	0.13	.016	-3.150	281	.002	-2.22	.70	-3.61	-.83
	Equal variances not assumed			-3.427	39.74	.001	-2.22	.64	-3.53	-.91

Table(4.13)Independent Samples Test between the Pancreas Tail Characteristics (CT Number and size) in both Normal Control Group (Group A) and the Diabetic patients (Group B)

		Levene's Test For Equality Of Variances		***T-Test For Equality Of Means***						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pancrease Tail CT Number	Equal variances assumed	3.093	.050	-3.77	280	.000	-9.68	2.56	-14.72	-4.63
	Equal variances not assumed			-3.22	35.13	.003	-9.68	2.99	-15.76	-3.59
Pancrease Tail size	Equal variances assumed	.016	.001	-2.91	281	.004	-1.70	.58	-2.86	-.55
	Equal variances not assumed			-2.72	36.52	.010	-1.70	.62	-2.97	-.43

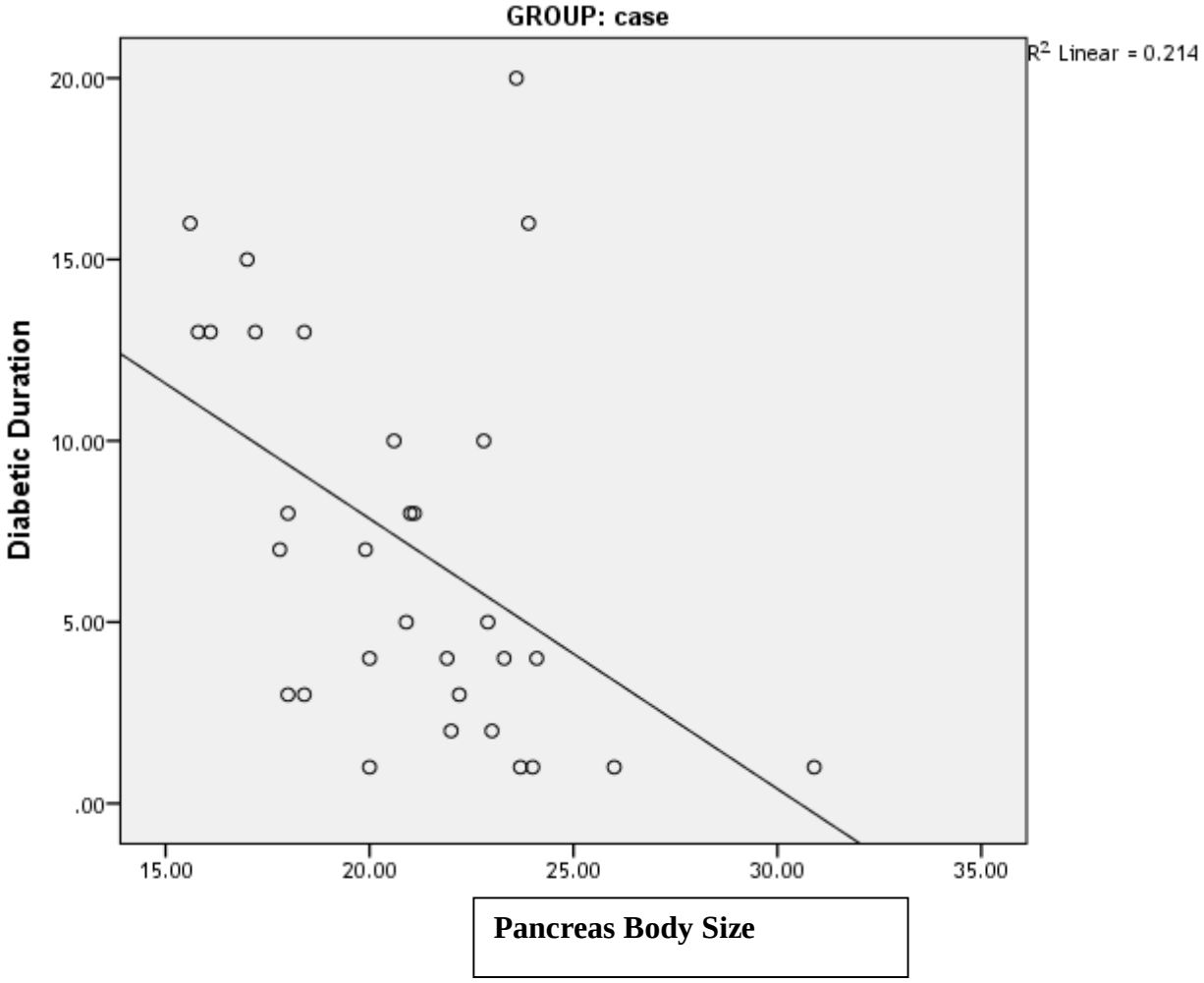

Figure 4.29 A scatter plot diagram shows Linear relationship between the pancreas Body Size and patient Diabetes Duration, The Contribution of Diabetes Duration to do change on the Pancreas Body Size is 21%

Predictive equation of Pancreas Body Size:-

Pancreas Body Size=22.755-0.745Xdiabetic duration

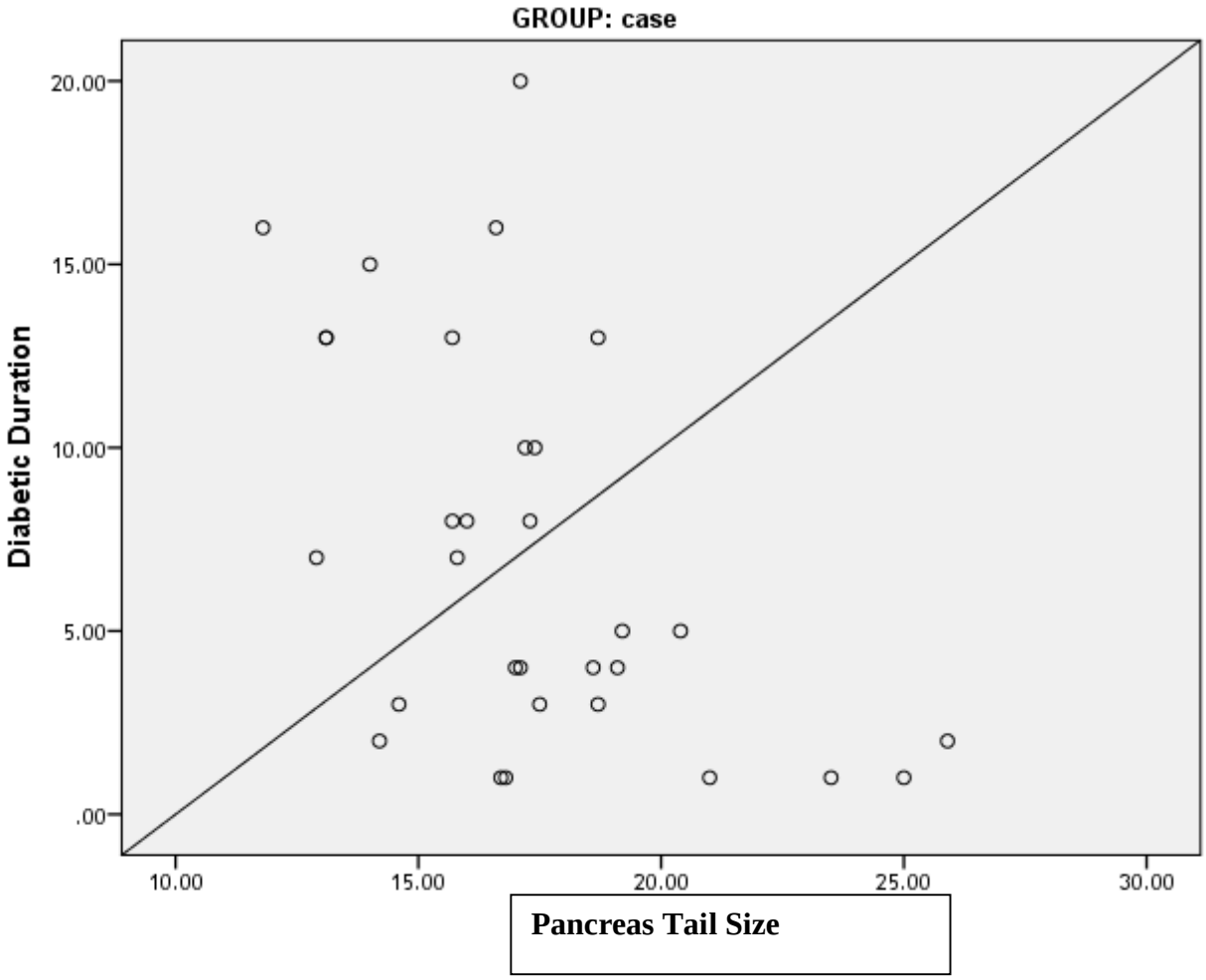

Figure 4.30 A scatter plot diagram shows Linear relationship between the pancreas Tail Size and patient Diabetes Duration, The Contribution of Diabetes Duration to do change on the Pancreas Tail Size is 22%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size=21.793-0.845Xdiabetic duration

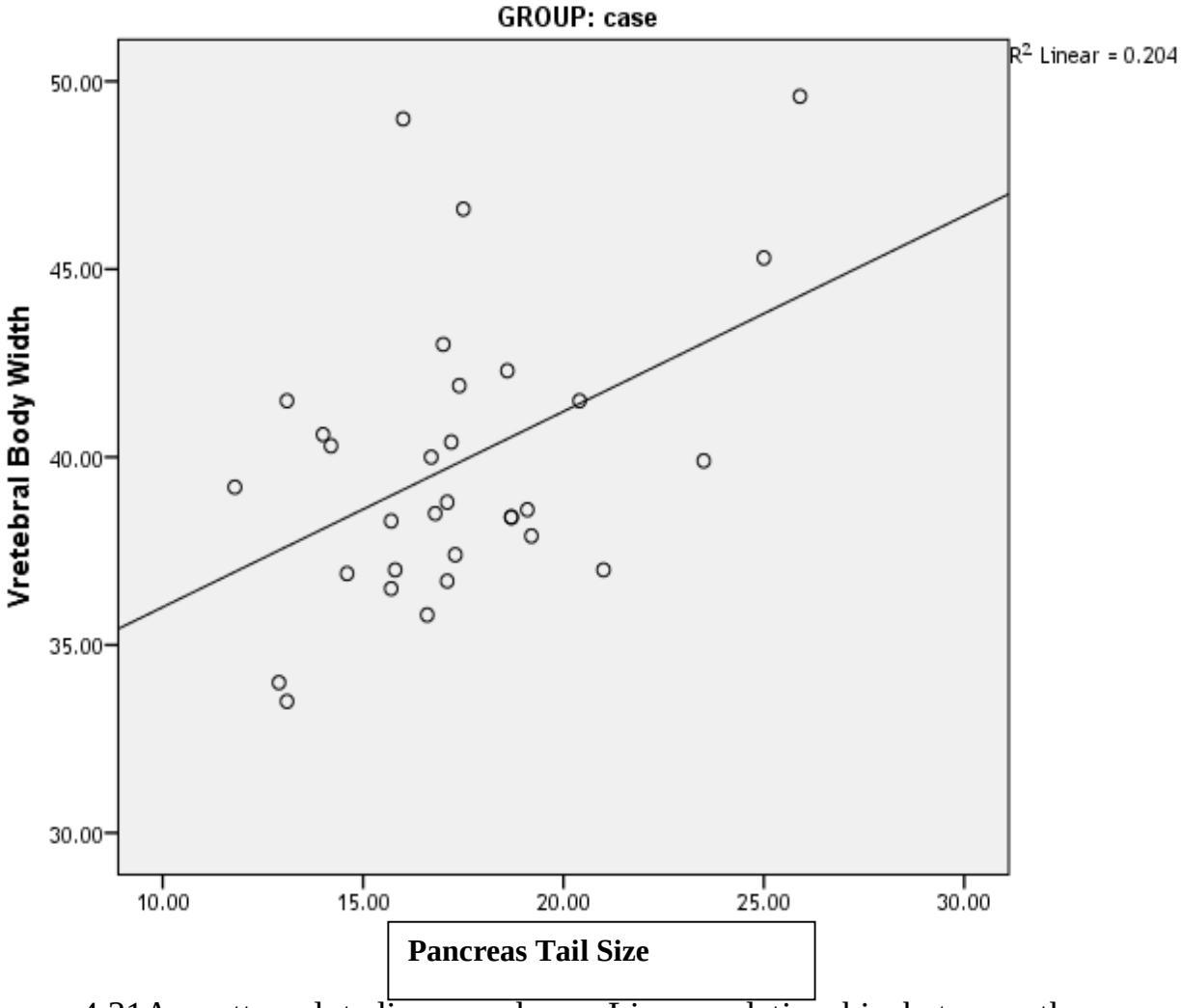

Figure 4.31A scatter plot diagram shows Linear relationship between the pancreas Tail Size and patient vertebra body width, The Contribution of VBW to do change on the Pancreas Tail Size is 22%

Predictive equation of Pancreas Tail Size:-

Pancreas Tail Size=30.80+0521Xvertebra body width

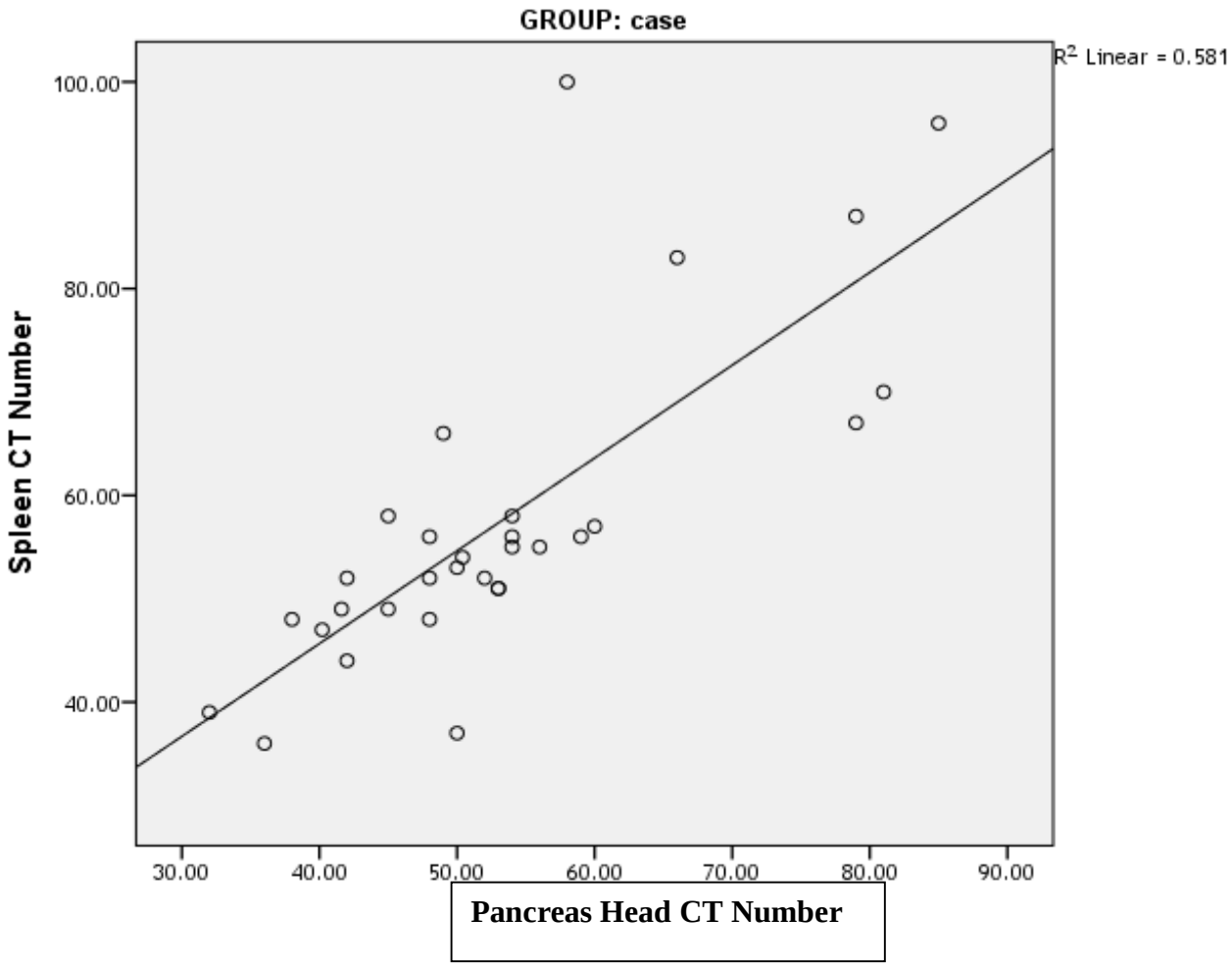

Figure 4.32 A scatter plot diagram shows Linear relationship between the pancreas Head CT and Spleen CT number, The relation of CT Number with the Pancreas head CT number is 58%

Predictive equation of Pancreas Head CT Number:-

Pancreas Head CT Number=9.752+0.898Xspleen CT Number

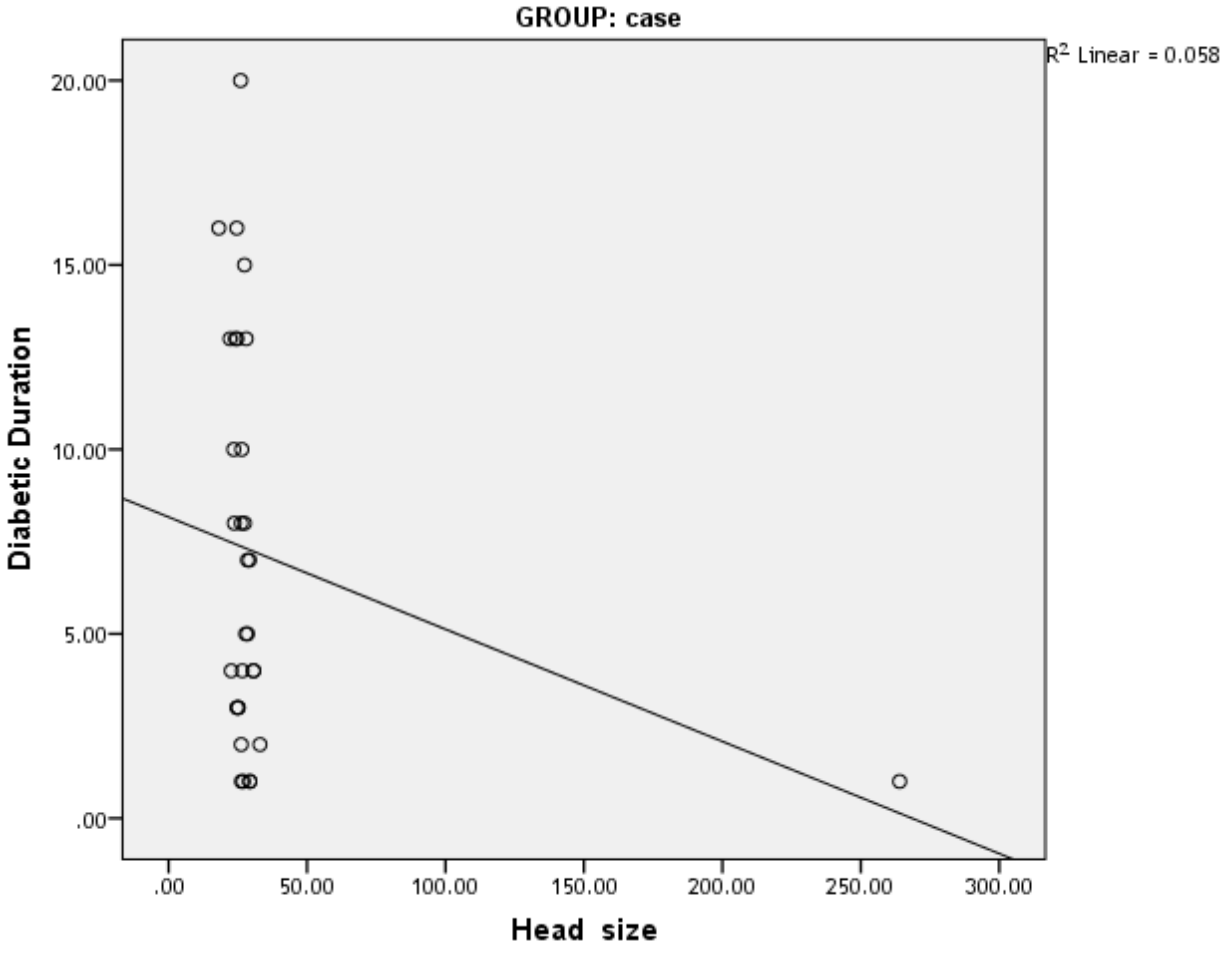

Figure 4.33 A scatter plot diagram shows Linear relationship between the pancreas head size and diabetes duration, the effect of duration to do change in pancreas head size is 58%.

Predictive equation of Pancreas Head size:-

Pancreas Head size =47.59-1.89 X diabetes duration

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion

The objectives of this descriptive study were to characterize the pancreas in Sudanese population by using CT scan in order to alleviate the discrepancy that arise in the pancreas measurement which attributed to body characteristic and to evaluate the effect of diabetes mellitus in the pancreas size regarding to disease duration .

The sample of this study consisted of 283 subjects with different genders, 191 were male and 91 were female. (252) were normal represent 89%considered as group (A), 31 were case group represent 11% of the total sample as seen in table 4.1 ,distribution of sample size according to gender showed that the males were more than females (table 4.2) in both groups.

The sample was classified according age starting from ages <10 and >50, this was presented in table 4.3 .

Descriptive Statistics mean and SD of the variables which includes age, height, weight, abdominal circumference, BMI , pancreas characteristic of head, body, tail CT number and size .In addition to reference values that include vertebral body size and its CT number and spleen CT number for both the normal control group (Group A) and Diabetes Patients (Group B) represented in table 4.4 .

The classifications of measurements and Ct number according to age for normal subject was found to be significant for all variables this was presented in table 4.5.

The readings of pancreas in diabetic patients (group B) were found to be in significant with age ,this was presented in table 4.6.

When considering the genders, a significant differences was detected for pancreas head, CT number, vertebral body width, vertebral body CT number and spleen CT number in both gender this was presented in table 4.7 but no significant different between the variables in both genders except vertebral body width this was presented in table 4.8.

As represented in table 4.9, the correlations between the pancreas characteristics and body characteristics for the normal control group (Group A) there are significant relation between the age and the density (CT number) of the pancreas head, body and tail p value at the level 0.021, .000 ,.000 respectively. Sudanese pancreas, head, body and tail texture can be measured when the subjects' ages were known. As the age increased the pancreas head, body and tail texture were decreased by 2% , 2% and 8% respectively figure 4.4 ,4.5 , 4.6. For pancreas CT number, can be predicted its values if the age was known by applying the following equations:

Pancreas Head ct number =50.102- 0.165 x age

Pancreas Body ct number =60.823 – 0.355 x age

Pancreas Tail ct number = 60.412 – 0.362 x age

reduction can be due to the fact that the structural and functional properties differ significantly in the exocrine and endocrine pancreas and age (Adhip et al, 1997) .A number of structural changes has been described in the aging pancreas. Results from earlier literature report that the organ decreases in weight after the sixth decade of life in humans, and it becomes harder and atrophic (Andrew et al, 1944, Laugier et al, 1991, Geokas et al,1985). In addition, histological changes such as ductal epithelial hyperplasia, intralobular fibrosis, and acinar cell de-granulation have been described. These morphologic changes in the aging pancreas have been ascribed to pancreatic involution leading to decreased secretory capacity of the exocrine

pancreas (Djuric-Stefanovic et al , 2012, Noronha et al ,1981).

In addition, there were significant relation between age and the size of pancreas body (p value.019) and tail (p value .040) The justification to have relation with age could be due to decline in the glandular tissue as well as the fatty connective tissue within the substance of the gland in elderly people and thinning atrophy of the gland, these findings agreed with Heuck et al, 1987 which they were performed abdominal computed tomographic scans on a group of 360 patients between the ages of 20 and 80 years ,they found that the anteroposterior pancreas diameter affected with age ,an increasing reduction of anteroposterior diameter of pancreatic body by 2%, and tail by 8% figure 4.7 ,4.8 .

For pancreas body and tail sizes can predict the measurement if the age was known by using the following equations:

Pancreas Body size =25.723+ 0.632 x age

Pancreas Tail size =27.415 + 0.680 x age

The study should that there was no relation between the pancreas head size and age.

Gender had no significant relation with pancreas head, body, tail antero posterior diameter. These results are matching with the results of. *Basnet* et al, 2011, they mentioned that there was no significant difference in the size of pancreas between males and females. The CT numbers measuring results of body and tail also were not affected with gender but pancreas head CT number showed with significant relation at p value .022.

The weight and body mass index represents no relation with pancreas head, body, tail, anteroposterior diameter and ct number of each part. Our result disagree with a study done by (Silva et al, 1993) reported that the diameters of the head, body, and tail of the pancreas measured by ultrasonography had

relation with BMI (Ogiu, 1977).

The normal samples height had a significant result with the CT number of the pancreas body (p= .029) the contribution of height to do change on it was 2% figure 4.9 and pancreas tail (p=.050), and the same result were with sizes of head, body and tail p=.000 for each one. Figure 4.10 showed Linear relationship between the pancreas Head size and patient Height for the control group, The Contribution of height to do change on the Pancreas Head sizes was 100%.*P*=0.000,14% on body and 16% on the tail. The pancreas head, body and tail sizes can be predicted if the subject height was known by the following equations:

Pancreas Head Size =22.319+0.083 X Subject Height

Pancreas Body Size =28.201 + 1.806 X Subject Height

Pancreas Tail Size =27.00 + 20262 X Subject Height

Significant correlation was detected between abdominal circumference and pancreas body and pancreas tail at p=0.015 ,0.026 and sizes p=.006 ,0.001 simultaneously. The contribution of abdominal circumference to do change on the pancreas CT number is 2%,3% on body size and 4% on tail size figure 13 ,14 ,15,16 .

body and tail ct number can be predicted if the subject abdominal circumference was known by the following equations:

Pancreas Body CT Number=100.670 - 0.234X abdominal circumference

Pancreas Tail CT Number=98.650-0.206Xabdominal circumference

body and tail sizes can be predicted if subject abdominal circumference was known by the following equations:

Pancreas Body CT Size=66.824+0.879Xabdominal circumference

Pancreas Tail Size=62.456+1.292Xabdominal circumference

Significant relation was shown clearly between VBW which was considered

as reference values and pancreas AP measurement and CT number. Vertebral body width had significant relation with pancreas part CT number; head, body and tail p=.016 ,.040, .021 respectively and similar result contributed with pancreas head size p=.006 ,body p=000 and p=018 with pancreas tail table 4.9. The contribution of vertebra body width to do change on the pancreas head size is 3% on the pancreas head, body and tail CT number is 2% figures (4.17 ,4.18 ,4.19). Contribution of vertebra body width to do change on the Pancreas Head size is 3% ,7% on body size and 2% on tail size figures (4.20 .4.21 ,4.22). Vertebral body ct number had significant relation with pancreas ct numbers of head p=.045, body CT number p=.010 and tail CT number p=000 table 4.9. The contribution of vertebra body CT number to do change on the pancreas CT number is 2% on head,3% on body and 1% on tail figure 4.23 ,4.24 ,4.25

For the reference values as vertebral size, CT number and pancreas measurement and CT number the following equations were also established:

For pancreas CT number, predicted its values if the vertebra body Width was n know :-

Pancreas head CT number=41.184 -0.44 x vertebra body width

Pancreas body ct number =41.020-0.042 x vertebra body width

Pancreas tail ct number =41.126 -0.045 x vertebra body width

For pancreas measurements, predict its values if the vertebra body width was known:-

Pancreas head size =34.561 +0.144 x vertebra body width

Pancreas body size =32.124 +0280 x vertebra body width

Pancreas tail size =14.713 +0.112 x vertebra body width

For pancreas CT number can predict its values if the vertebra CT number was known:-

Pancreas head CT number=226.925 +0.461 x vertebra CT number

Pancreas body CT number =215.39 +0.667 x vertebra CT number

Pancreas tail ct number = 196.446 +1.041 x Vertebra ct number

Regarding to the reference values also spleen CT number showed significant relation with ct number values of pancreas head, body, tail and head of pancreas size p=0.000 for each part. We found that the contribution of spleen CT number to have relation on the pancreas head CT number is 26%, on pancreas head and, 30%on pancreas body, and 36% 0n pancreas tail spleen CT number has relation with pancreas tail CT number with greatest percentage value figure 4.26 ,4.27 ,4.28

For pancreas CT number we can predict its values if the spleen CT number was known:-

Pancreas head CT number =30.173+0.500 x spleen CT number

Pancreas body CT number =25.199 +0603 x spleen CT number

Pancreas tail CT number = 30.173 +0.500 x spleen CT number

Pancreas Head CT size =34.561 +0.144 x vertebra body Width

The pancreas texture was reduced significantly at P value 0.016 for head, .040 .021 for body and tail as the vertebra body size and texture increased, but the texture increased when the spleen texture increased.

The difference in Texture (CT number) of the pancreas head, body and tail in the CT images, were justified to be due to pancreas differentiation of cells, its proceeding through two different pathways, corresponding to the dual endocrine and exocrine functions of the pancreas (El-Hodhod et al, 2005).

In progenitor cells of the exocrine pancreas, important molecules that induce differentiation include follistatin, fibroblast growth factors, and activation of the notch receptor system (Adhip, 1997). Development of the exocrine acini progresses include the pre-differentiated, proto-differentiated, and

differentiated stages, which correspond to undetectable, low, and high levels of digestive enzyme activity, respectively. That means the difference in structure and function might cause those differences in texture (CT number readings) for the pancreas head, body and tail, as the pancreas is being a mixed gland. The importance of the knowledge about the pancreas normal size; is that the pancreas size is very important in the evaluation of protein energy malnutrition patients, and these measures could also be used as a predictive parameter and any changes in size may affect its function (Vesterhus et al, 2008).

Correlations between the pancreas characteristics and body characteristics for the diabetic patients (Group B) was represented in table 4.10 which was illustrated that significant results between the size of pancreas head, body and tail and duration of diabetes p=0.015 , 0.009 ,0.003. The size of the pancreas was smaller in diabetic patients than in control group . This results agree with results of previous studies of many authors; (RaviRajput et al, 2001; Alzaid et al, 1993; Reza et al 2007). They mentioned that that diabetes affect the pancreas size. While the pancreas texture had no significant relation with diabetic durations.

A scatter plot diagram showed significant results with pancreas size3+. Linear relationship between the pancreas head body and Sizes and patient diabetes duration, same results represented by (Reza et al , 2007) described that In type I diabetes, decrease in the size of pancreas was more prevalent than in type II diabetes and these changes become more prominent time over, but our study does not consider the type of diabetes.

As seen in Figure 4.30 a scatter plot diagram shows linear relationship between the pancreas Tail Size and patient diabetes duration, the contribution of diabetes duration to do change on the pancreas tail size is

22%., and the contribution of diabetes duration to do change on the Pancreas body size is 21% figure 4.29 i.e. aged diabetic pancreas reveals with pancreas body decline. Some of the patients in the research were used insulin and the others used tablets but our study does not consider the type of diabetes.

For pancreas measurements, the change can be predicted if the duration of diabetes was known:-

Pancreas head size 47.59-1.89 x diabetes duration

Pancreas body size = 22.755-0.745 x diabetes duration

Pancreas tail size = 21.793 -0.845 x diabetes duration

Independent samples test between the pancreas head characteristics, Body characteristics, tail characteristics (CT Number and size) in both normal control Group (Group A) and the diabetic patients (Group B) presented in tables (4.11), (4.12) and (4.13) showed significant result p=0.002, p=000, p= .059 ,.016 respectively, p=.050 ,.001 respectively, for both CT number and size.

In this study the mean values of the normal pancreas size was found to be up to 28.16 $\pm$ 3.37 for head,23.19 $\pm$ 3.74 for the body and 19.05 $\pm$3.05 for the tail ,this results were differ from international previous studies done by. Kreel L et al saied that the size of the normal pancreas was found to be up to 3.0 cm for the head, 2.5 cm for the neck and body, and 2.0 cm for the tail, also George Štefánek, 2011 measured the sizes in pancreas, and found that pancreatic head is < 30mm, Pancreatic body <20mm, Pancreatic tail <25mm.

5.2 Conclusion:

Pancreas in Sudanese have been evaluated for both measurements and texture (CT number) considering the vertebral body width and spleen CT number as reference. Measurement were taken for normal subjects showed values which were considered to be as reference for Sudanese.

Pancreas antropostrior measurement was found to be 28.16 $\pm$ 3.37 for head, 23.19 $\pm$ 3.74 for body, 19.05 $\pm$ 3.05 for tail and the CT number for normal pancreas was found to be 59.02 $\pm$ 14.17 for head and 57.22 $\pm$ for 12.59 for body and 55.44 $\pm$ 13.12 for tail.

The measurement of the pancreas body and tail had significant relation with age, and abdominal circumference. The head, body and tail had same result with height, vertebral body width. The pancreas texture had significant result with age, vertebral body width vertebral body CT number, and spleen CT number, the head texture had with gender, the body and tail texture had same result with height and abdominal circumference, standard reference for pancreas measurement and texture were established for normal Sudanese subjects. New equations were established to predict pancreas measurement for patient with known age, height, abdominal circumference.

The study showed that the measurement of diabetes patients were less than the measurement found in the normal control group. The pancreas CT number was not affected with diabetes.

5.3 Recomendation

- Its recommened to concider these measurments as refrence values when the pancreas is to be evaluated.
- Larger discriptive analytic studies are needed using another imaging method as MRI or US to confirm these results that were presented in the index so as to help in a perfict diagnosing of pancreatic problem which lead to elargment or dicreasing its size or its density (CT nomber).
- Farther reseach for measuring the pancreas of diabetic sudanese population regarding the type drug used.
- Because CT scan plays a big rule in imaging of pancreas there for it is recommended to be used as a diagnostic method in pancreatic diseases.
- As the morphology differs regarding the race and ethnicity factor a similar local research is recommend in different Sudanese tribes.

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Appendix

Appendix (1)

Sudan University of science and technology

Collage of Graduate Studies

Data collection sheet of Characterization of Pancreas in Sudanese population using computerize tomography (CT)

Data collection sheet for Sudanese population for Diabetic patients

NO.	Age	sex	Height	weight	Body mass index	ABD .CIR	Pancreas measurement						VB	VB. CT.	Spleen ctNo	Diabetus	
							H.CT NO	Head size	Body size	B.Ct NO	Tail size	T.CT NO				Duration	Type of Drug
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Sudan University of science and technology

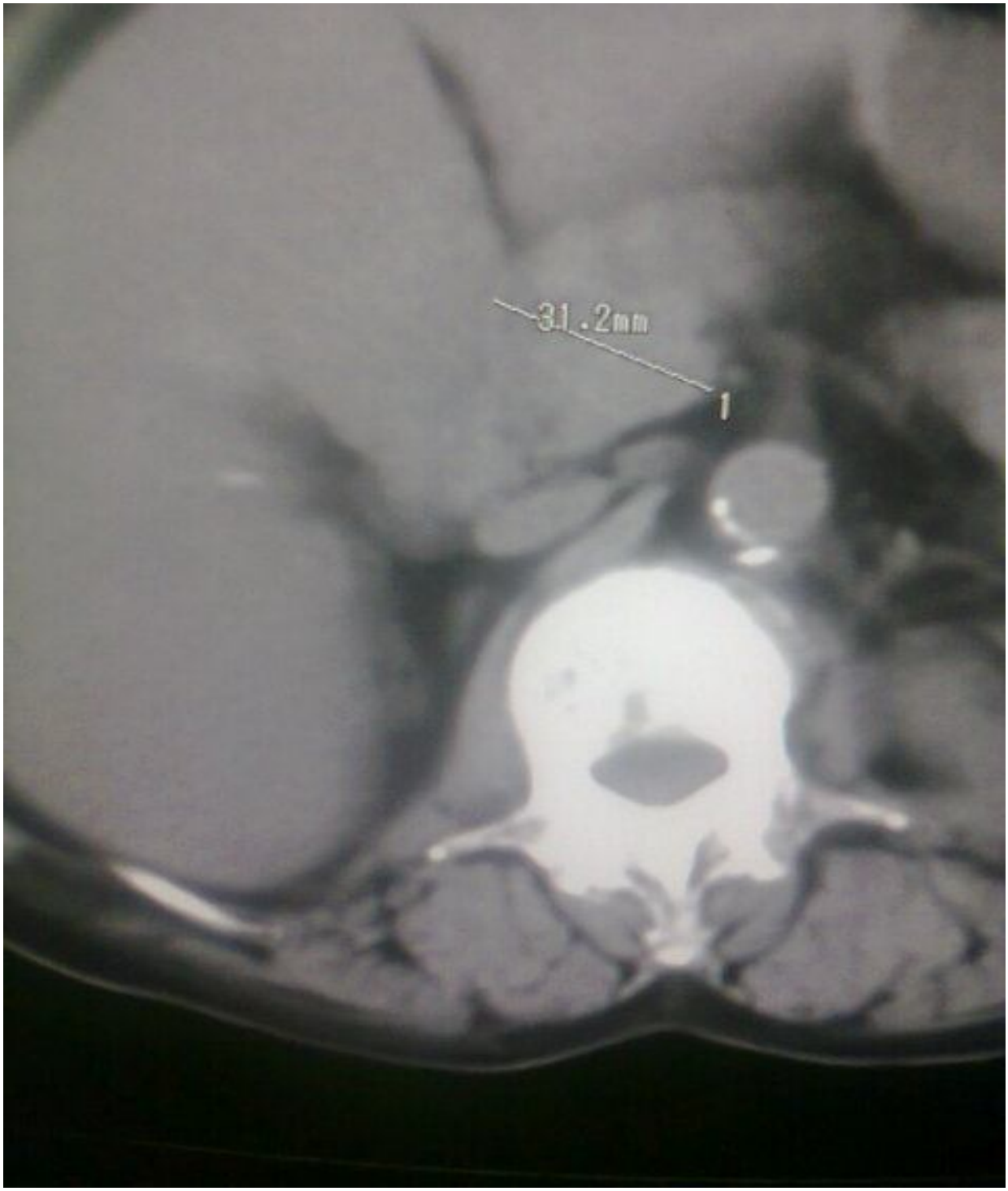
Collage of Graduate Studies

Data collection sheet of Characterization of Pancreas in Sudanese population using computerize tom

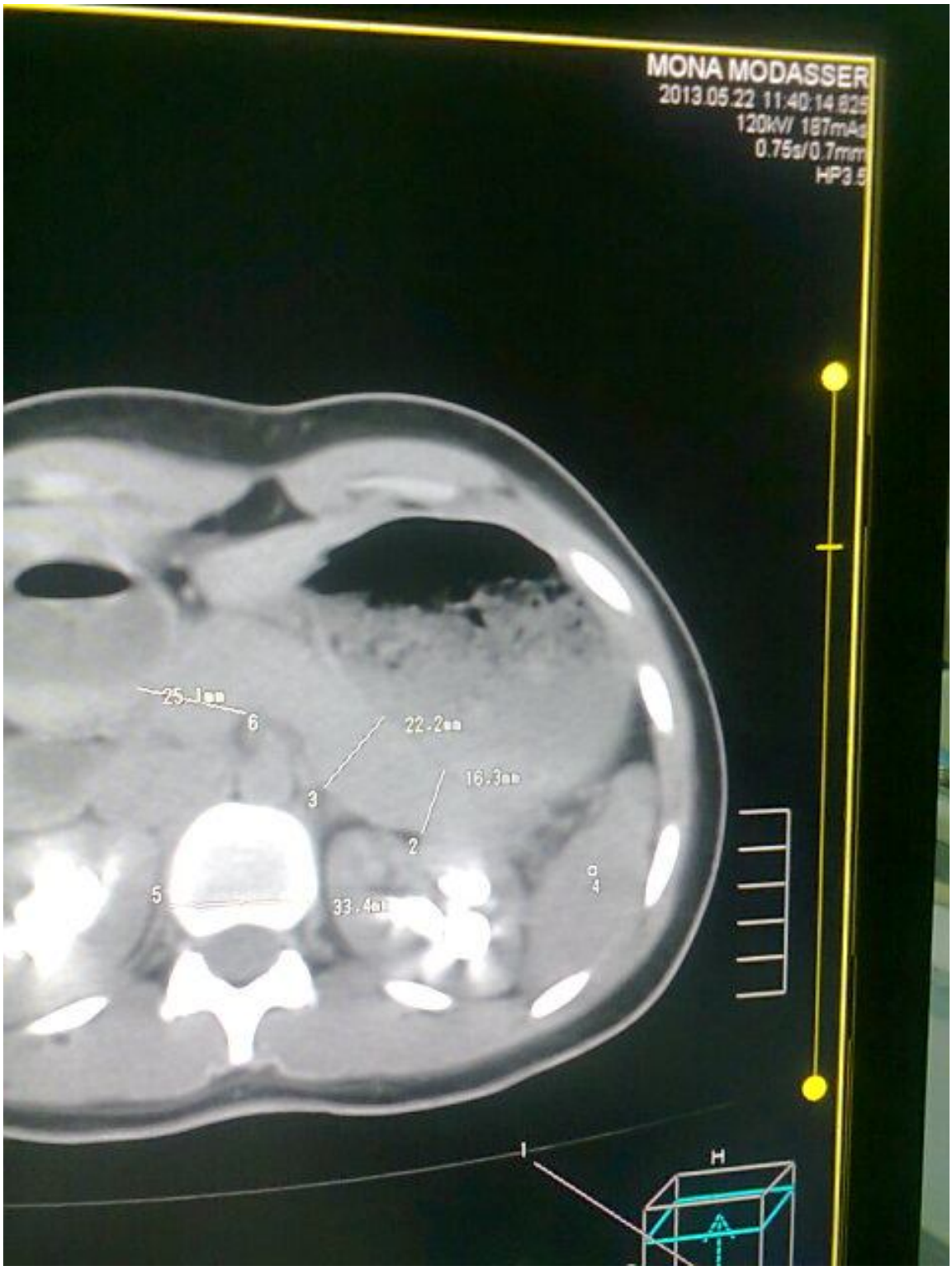
Data collection sheet for Sudanese population index

NO.	Age	sex	Height	weight	Body mass index	ABD. CIR	Pancreas measurement						VB
							H.CT NO	Head size	Body size	B.Ct NO	Tail size	T.CT NO	
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

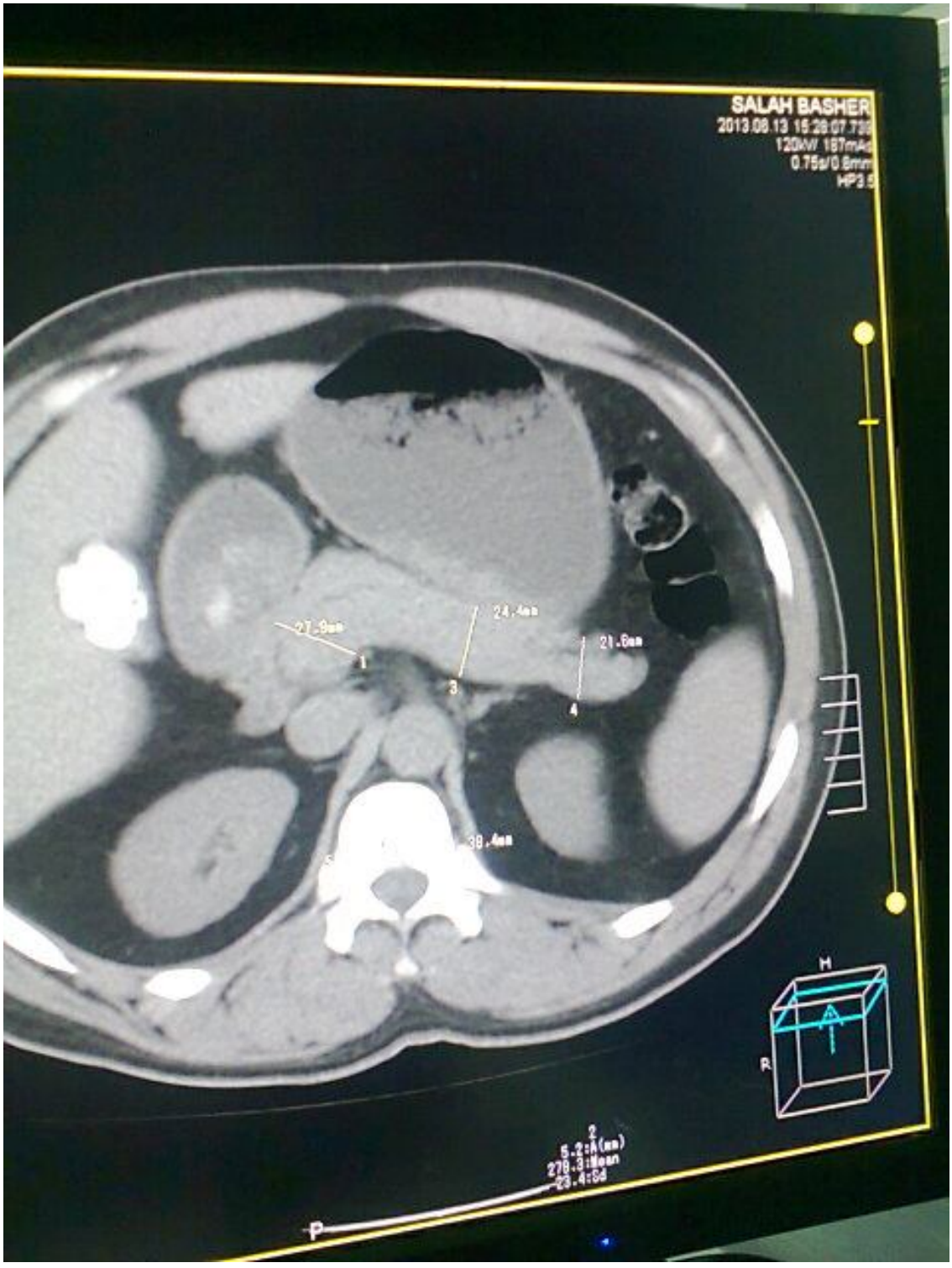
Appendix 2



Measurement of pancreas head for normal patient



Measurement of pancreas for diabetic patient



Measurement of pancreas for normal patient