Sudan University of Science and Technology

College of Graduate Studies

Measurement of Pancreas in Sudanese Population Using Computerized Tomography

A proposal Submitted for the Requirements of the fulfillment of the Award Ph.D. Degree in Medical Diagnostic Radiologic

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Dedication

I dedicate this work for my mother, father, husband, then to my small and big family, my friends, and for everyone who teaching me something through my educational journey.
To all those whom supported , participated, and advice me through this research.

Acknowledgement

Deep thanks to my supervisor **Dr. Hussein Ahmed Hassan,** for her contact supervision, inexhaustible patience &unlimited help.

Our thanks extend to staff of Alkwity Specialized Hospital and modern medical center for help.

Thanks everyone who helped, supported and provided any type of help through this study.

Finally, special thanks to our families and friends who were of helpful during the whole study period.

ABSTRACT

This study was conducted to define the normal pancreas size and texture for Sudanese population using CT scan .

Computerized tomography scanning was performed in the Radiology unit of the ALSAHA hospital ,ALKAUTY SPECILAIZE HOSPITAL and MODREN ADICAL CANTER in Khartoum –Sudan period Aug2019 to Oct2019.

The data was collected from (100) patients was normal pancreas ,patient age ,gander , head of pancreas size ,body of pancreas size ,tail of pancreas size ,head of pancreas CT number ,body of pancreas CT number and tail of pancreas CT number was measured .

The data was presented as mean and comparative association hypothesis tests (0.05 sig level).

The study revealed that the Sudanese pancreas size was 25.46+-6.764mm mean of head ,45.61+-15.336mm mean of body and 44.02+-16.686mm mean of tail .

The study showed elation between the pancreas size and subject's age ,and non relation between the pancreas size and subject's gander .

ملخص الدراسه

دراسة وصفية تحليلية تهدف لقياس أبعاد البنكرياس وكثافته لدى السودانيين. أجريت في مستشفي الساحه ,المستشفي الكويتي التخصصي والمركز الطبي الحديث في الخرطوم – السودان في الفتره من اغسطس 2019 الي اكتوبر 2019 .

تم جمع (100) عينه بحثيه لمرضي سليمين البنركرياس خضعوا لإجراء فحص الأشعة المقطعية المحوسبة للبطن باستخدام جهاز أشعة مقطعية متعددة المقاطع، تم تسجيل العمر والنوع تم قياس أبعاد البنكرياس أمامي خلفي عند منطقة الرأس والجسم والذيل وتم أيضا قياس كثافة نسيج البنكرياس عند كل من الأجزاء الثلاثة .

كشفت الدراسة أن حجم البنكرياس للسودانين كان 25.46±6.764 ملم متوسط الرأس و 45.61 ±15.336 ملم متوسط الجسم و 44.02 ±16.686 ملم متوسط الذيل.

يوجد ارتباط معنوي بين قياسات البنكرياس والعمر ولا يوجد ارتباط بين قياسات البنكرياس والنوع .

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Chapter One

1.1Introduction

Prelude: 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 , 2019).

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 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

1.3 Objectives of the study:

1.3.1General objective

Measurement of Pancreas in Sudanese Population Using Computerized Tomography

1.3.2 Specific Objectives:

- To measure the pancreas head, body and tail size, in addition to density (texture) using CT Hounsfield Unit.
- To correlate the pancreas measurements and texture age and gender in Sudanese population

1.4 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 5 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

2.1 Embreolic Development of the pancreas:

A region within the endoderm 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).

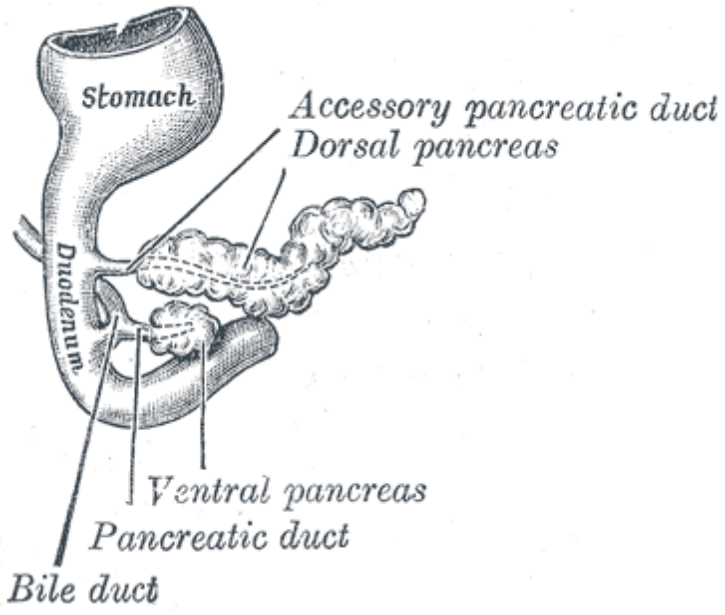


Figure 2.1 Pancreas of a human embryo of five weeks (Williams PL,1998).

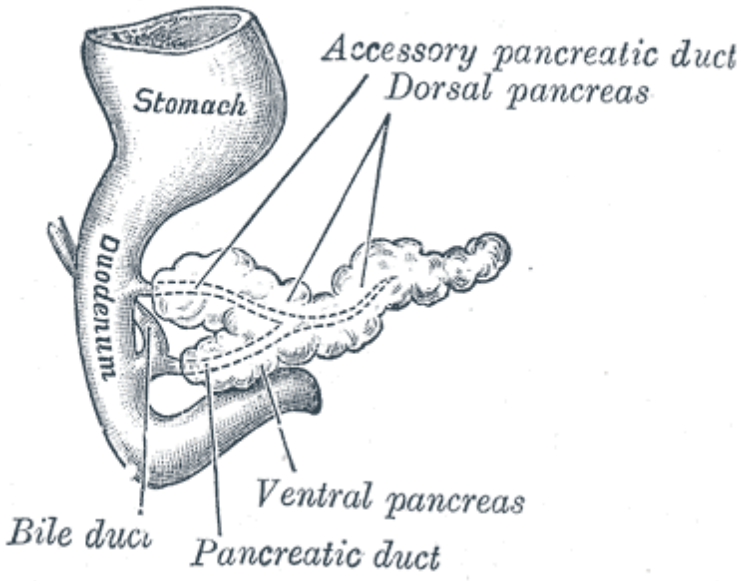


Figure 2.2 Pancreas of a human embryo at end of sixth week. (Williams PL,1998).

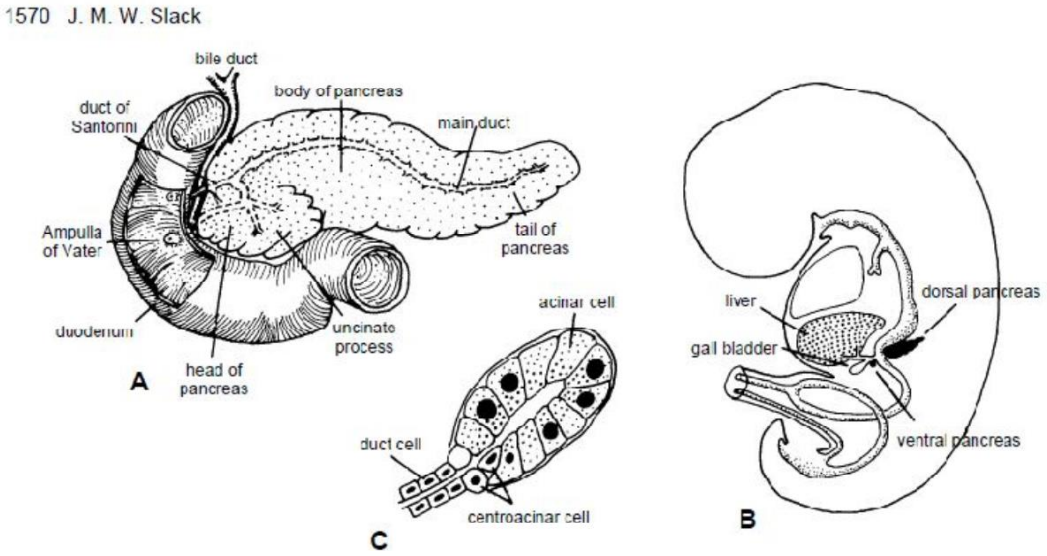


Figure 2.3. (A) Anatomy of the adult human pancreas (B) Location of the dorsal and ventral pancreatic buds in a human embryo of about 36 days (C)Hisotolgy of a pancreatic acinus (Slack, 1995).

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).

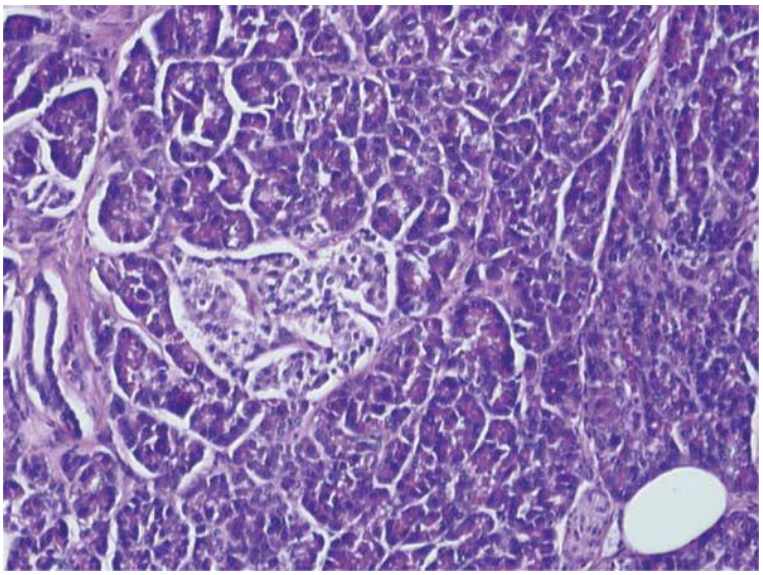


Figure 2.4 Histologic section of human pancreas obtained at autopsy shows dense-staining acinar cells and a light-staining islet of Langerhans just left of the center of the field. A small duct is visible on the left side of the illustration (9 o'clock position). Hematoxylin-eosin stain; ×140.

(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 .

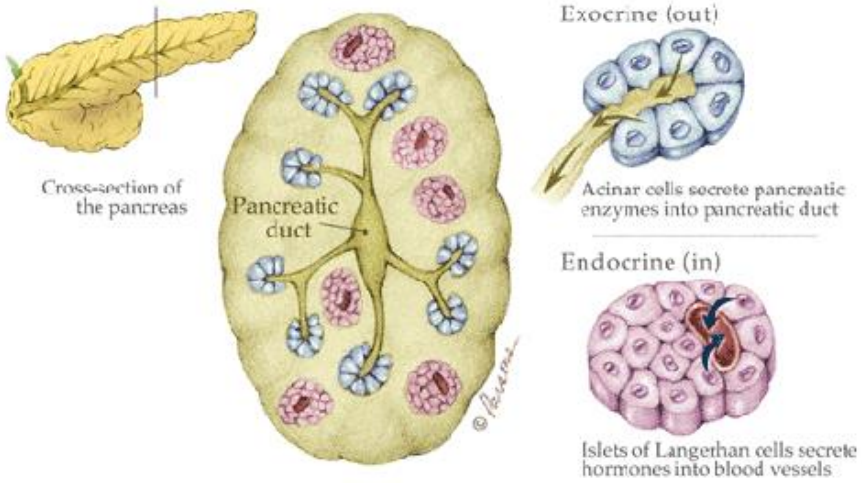
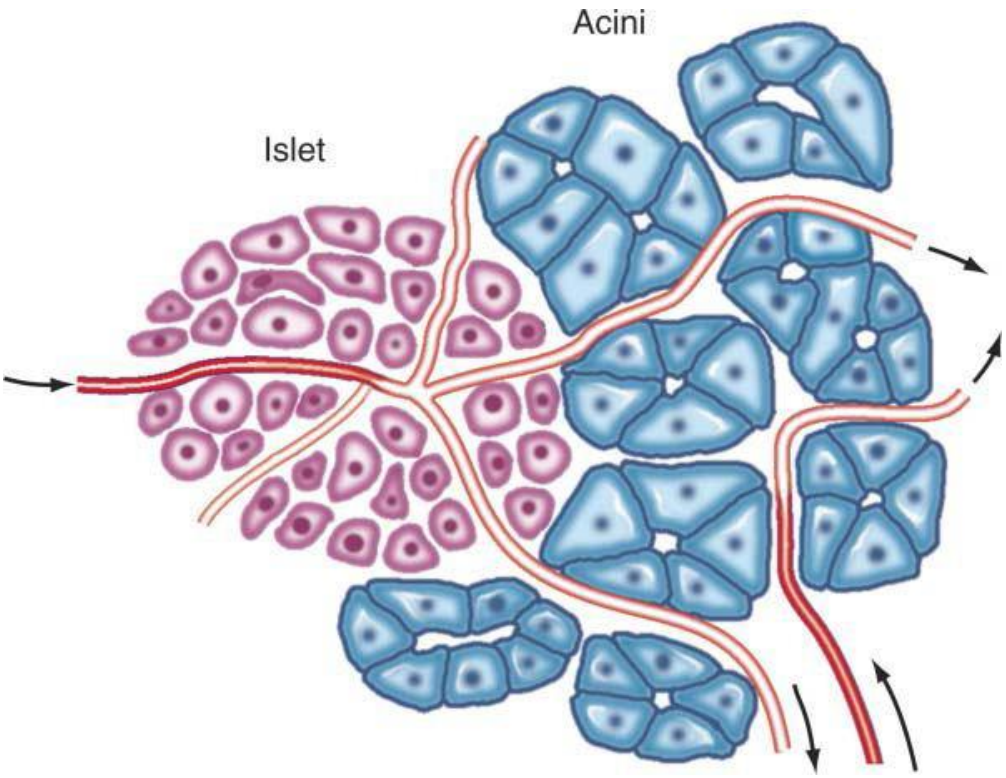


Figure 2.5 Histology of Pancreas (Baltimore, 2011).

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)



11 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.

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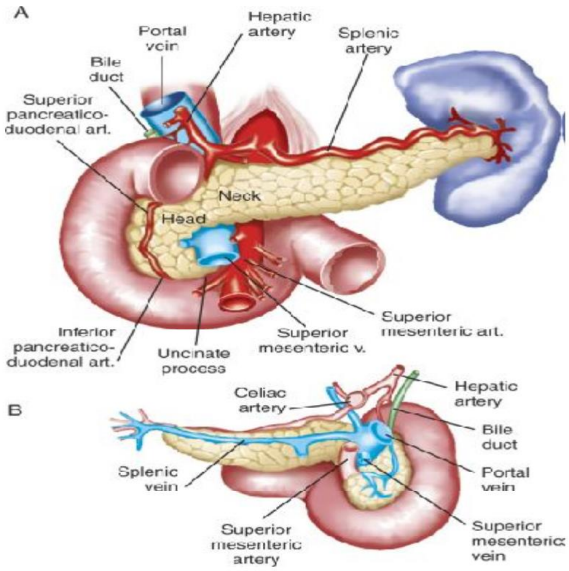

Figure 2.7 Diagrammatic representations of the pancreas. A, Anterior view; B,posteriorview.(http://www.mdconsult.com/das/book/body/107705462-4/0/1389/383.html).

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)

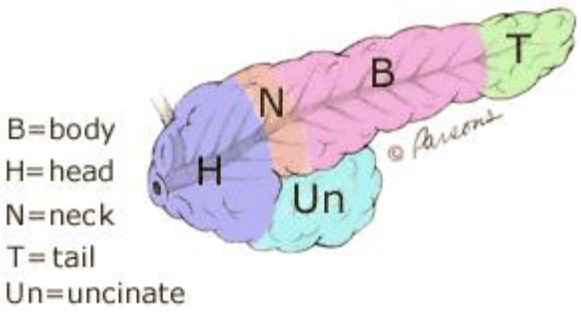

Figure 2.8 Diagrammatic representations of the pancreas. Head, Body ,Tail and uncinate.

(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).

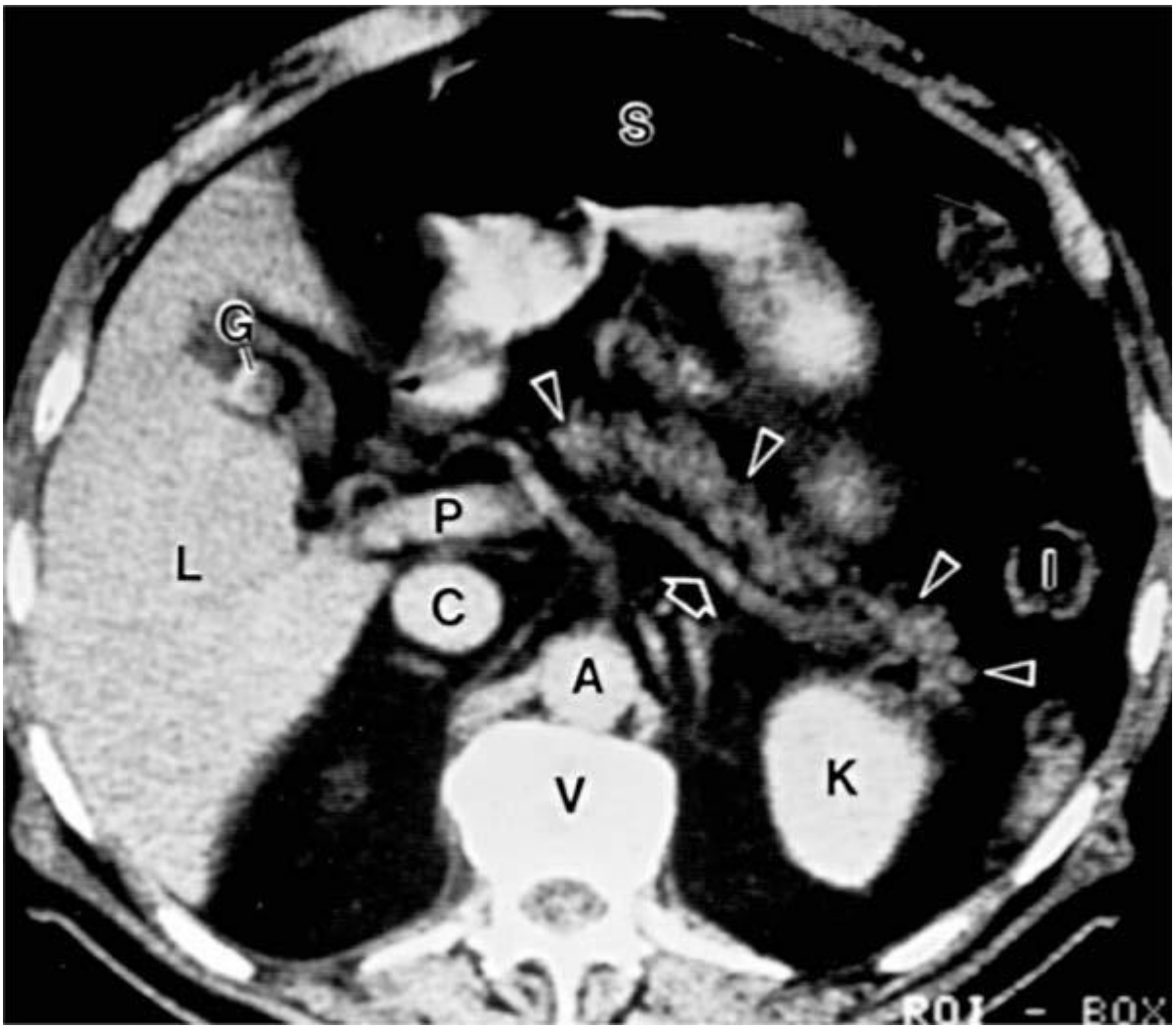

Figure 2.9 Normal anatomic relation of the pancreas with other intraabdominal structures as shown by computed tomography. The borders of the pancreas are indicated by arrowheads. The splenic vein is indicated by an arrow. A, aorta; C, vena cava; G, incidental gallstone; I, small intestine; K, left kidney; 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

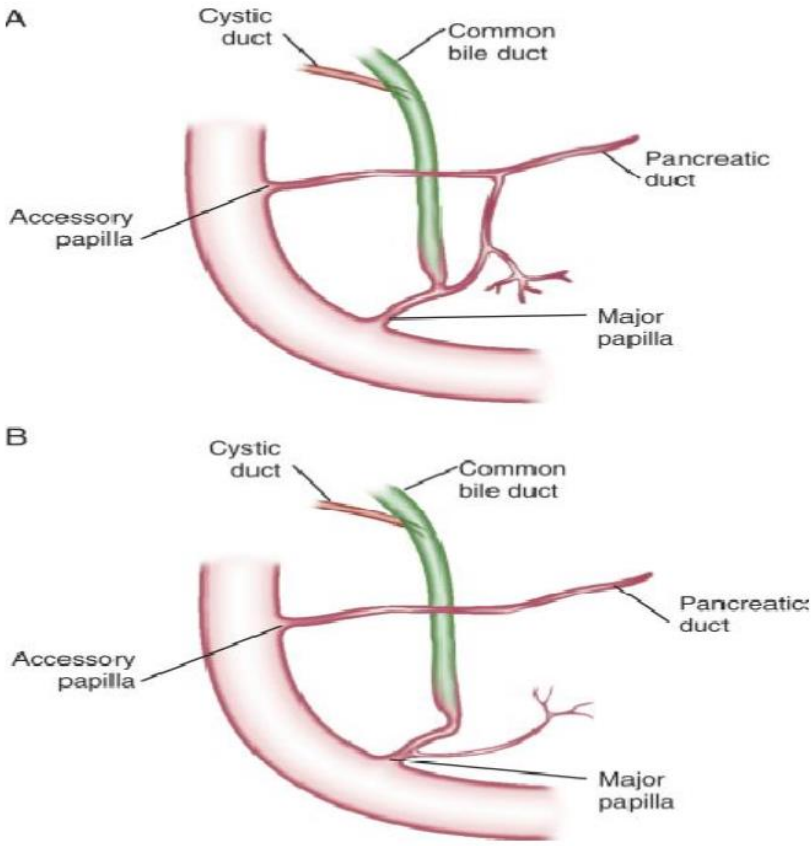

Figure 2.10 Anatomic arrangement of the pancreatic duct system. A, The most common arrangement. Most of the pancreatic secretion empties into the duodenum along with bile through the major papilla. The proximal portion of the embryonic dorsal pancreatic duct remains patent in about 70% of adults and 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 an 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).

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 pancreaticoduodenal 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)

2.6 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).

2.7 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 Xray 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 usinga 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).

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).

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).

Chapter Three

Materials and Methods

3.1 Study Design

This was descriptive analytical study. It was achieved at radiology department Alsaha Hospital , Modern Medical Center &Kuwait Specialist Hospital during the period from August 2019 to Oct2019

3.2 Sample

3.2.1 Inclusion Criteria

A total of 100 patients include normal , their mean age was 40.37±16.05years. Patients were in both genders, patients were selected for abdominal CT, CT KUB, and CTU. Patients age, gender, pancreases head CT number, pancreas body CT number, pancreas Tail CT number, pancreas head size, pancreas body size, pancreas tail size for normal patients .

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

100 Sudanese subjects who were scanned for abdomen CT and were diagnosed as normal pancreas and had no history of disease affected pancreas were included . 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 CT numbers for the pancreas head, body and tail were measured and named as pancreas texture (measured in Hounsfield Unit).

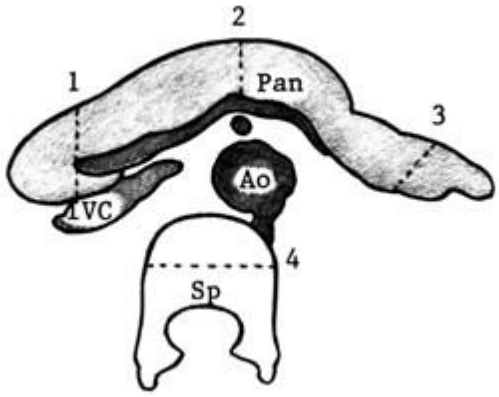

Figure 3.1 shows the method of pancreas measurements

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

Results

Statistical Methods: comparative analytical method was used, using SPSS statistical program based on descriptive statistics and comparative associational hypothesis tests (0.05 sig. level), to evaluate the mean pancreas size among Sudanese adults and to demonstrate the differences in mean size (head, body and tail) with respect to (gender and age).

The student-t test and F test were used to study the hypothesis.

Table (4.1): Participants distribution with respect gender:

Gender	Frequency	Percent
Male	59	59.0
Female	41	41.0
Total	**100**	**100.0**

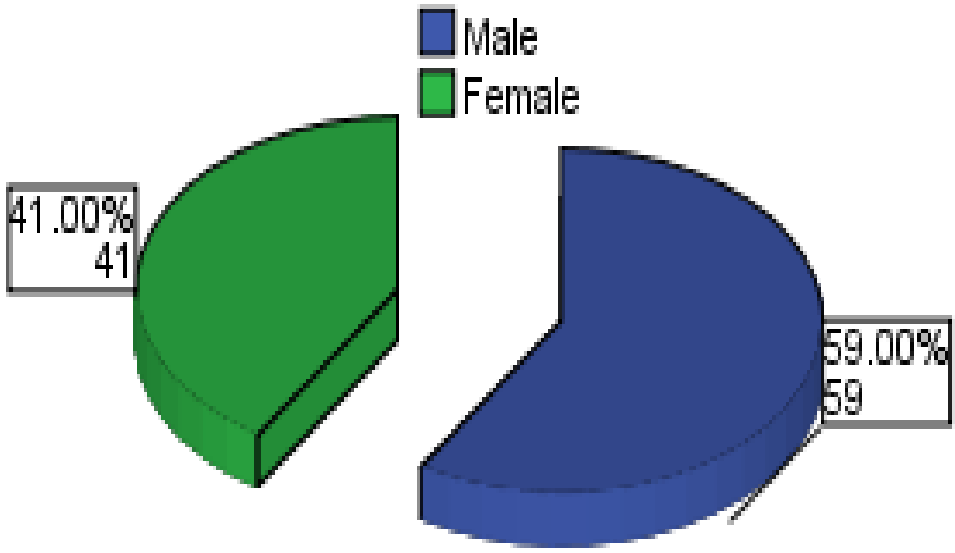

Figure 4.1: distribution of participants according to gender

Table (4.1) and figure (4.1) show that most (59%) of participants are males, while (41%) of them are females.

Table (4.2): Participants distribution with respect to age:

Age	Frequency	Percent
Less than 30 years	22	22.0
30-40 years	27	27.0
41-50 years	21	21.0
51-60 years	12	12.0
61-70 years	10	10.0
More than 70 years	8	8.0
Total	**100**	**100.0**

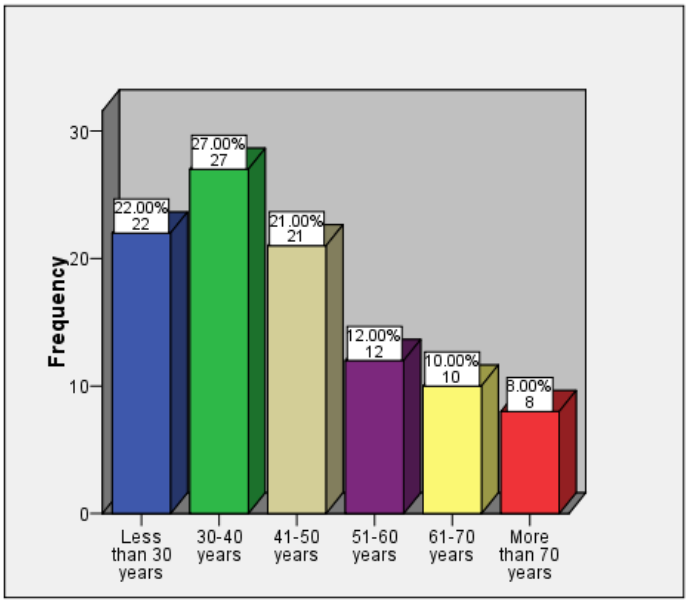

Figure (4.2): Participants distribution with respect to age

Table (4.2) and figure (4.2) show that (27%) of participants were (30-40) years old, since (22%) of them were less than 30 years and (21%) of them 41-50 years, while (12%) of them were 51-60 years old and (10%) of them were 61-70 years, whereas only (8%) were more than 70 years old. Therefore, most of the participants were (less than 50 years old).

Table (4.3): Descriptive Statistics for pancreas parts sizes

N=100	Minimum	Maximum	Mean	Std. Deviation
Head	10	55	25.46	6.764
Head CT No.	22	80	48.18	13.966
Body	14	82	45.61	15.336
Body CT No.	9	35	20.81	5.979
Tail	15	88	44.02	16.686
Tail CT No.	9	33	18.03	5.489

Table (4.3) shows that a total of (100) adult Sudanese were selected, whom present (10-55 mm with 25.46±6.764 mm mean of pancreas head), (14-82 mm with 45.61±15.336 mm mean of pancreas body), and (15-88 mm with 44.02±16.686 mm mean pancreas tail).

Table 4.4: Mean pancreas size with respect to gender:

	Gender	Mean	Std. Deviation
Head CT No.	Male	47.73	12.319
	Female	48.83	16.186
Head	Male	25.08	5.150
	Female	26.00	8.617
Body CT No.	Male	20.98	6.118
	Female	20.56	5.840
Body	Male	46.86	13.634
	Female	43.80	17.519
Tail CT No.	Male	18.73	5.420
	Female	17.02	5.498
Tail	Male	45.00	16.000
	Female	42.61	17.733

Table (4.4) provides useful descriptive statistics for the two groups that we compared, including the mean and standard deviation.

Table 4.5: t-test for equality of mean pancreas size for males and females:

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Head CT No.	-0.368	71	0.714	-1.100	2.994
Head	-0.664	98	0.508	-0.915	1.379
Body CT No.	0.346	98	0.730	0.422	1.221
Body	0.981	98	0.329	3.060	3.119
Tail CT No.	1.534	85	0.129	1.704	1.111
Tail	0.703	98	0.484	2.390	3.401

T-test results will tell us if the mean size and CT No. of pancreas (head, body and tail) for the two groups were statistically different (significantly different) or they were relatively the same.

We can see that the male and female means for (Head CT No. and Head), (Body CT No. and Body) and (Tail CT No. and Body CT No.) are statistically, non-significantly different because the all values of P-values in "Sig. (2-tailed) are more than 0.05. Looking at the **Distributions of two groups table (4.4) above**, we can conclude that there is no statistically significant difference between the pancreas (head, body and tail) mean for males and females.

Table 4.6: Mean pancreas size with respect to age:

		Less than 30 years	30-40 years	41-50 years	51-60 years	61-70 years	More than 70 years	Total
Head CT No.	Mean	46.82	52.37	47.57	46.17	44.3	47.25	48.18
	Std. Deviation	14.342	16.427	12.816	11.984	7.009	16.645	13.966
Head	Mean	24.95	25.15	24.1	26	26.6	29.25	25.46
	Std. Deviation	5.131	4.753	6.041	5.326	5.7	16.369	6.764
Body CT No.	Mean	22.77	21.11	17.9	23.58	20.9	17.75	20.81
	Std. Deviation	7.064	5.199	5.356	6.007	4.202	5.701	5.979
Body	Mean	54.09	52.74	34.71	42.17	39.6	39.5	45.61
	Std. Deviation	12.386	16.603	12.725	7.975	16.668	5.425	15.336
Tail CT No.	Mean	19.64	17.63	17.86	18.75	15.7	17.25	18.03
	Std. Deviation	5.819	4.765	5.977	5.529	4.057	7.126	5.489
Tail	Mean	49.55	45.85	42.33	41.17	36	41.38	44.02
	Std. Deviation	16.294	19.09	15.929	13.341	11.065	19.856	16.686

Table (4.6) provides useful descriptive statistics for the age groups that we compared, including the mean and standard deviation.

Table 4.7: ANOVA table for difference between age groups in mean of pancreas size:

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Head CT No.	Between Groups	728.781	5	145.756	0.737	0.597
	Within Groups	18581.979	94	197.681		
	Total	19310.760	99			
Head	Between Groups	178.769	5	35.754	0.773	0.572
	Within Groups	4350.071	94	46.277		
	Total	4528.840	99			
Body CT No.	Between Groups	431.734	5	86.347	2.612	0.029
	Within Groups	3107.656	94	33.060		
	Total	3539.390	99			
Body	Between Groups	6250.434	5	1250.087	6.899	0.000
	Within Groups	17033.356	94	181.206		
	Total	23283.790	99			
Tail CT No.	Between Groups	127.101	5	25.420	0.837	0.527
	Within Groups	2855.809	94	30.381		
	Total	2982.910	99			
Tail	Between Groups	1618.890	5	323.778	1.173	0.328
	Within Groups	25945.070	94	276.011		
	Total	27563.960	99			

Table (4.7) shows the results of (1-Way ANOVA) test for differences between subjects (age groups) in mean pancreas size as in table (4.6). We take a look at the (Sig. value) in the last column; which determine if the different age groups were relatively have the same pancreas size or if they were significantly different from one another. The Sig. value for head, tail and their CT No. are more than 0.05, and we can conclude that the differences in pancreas's heads and tails with respect to age are likely due to chance and they are relatively the same for different age groups, while the differences in pancreas's body and its CT No. depend on age, since the Sig. values are less than 0.05, therefore, pancreas's body size and its CT No are different for different age groups.

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. The sample of this study consisted of 100 subjects with different genders, 59 were male and 41 were female. Table (4.1) and figure (4.1) show that most (59%) of participants are males, while (41%) of them are females.

The sample was classified according age starting from ages <30 and >70 , this was presented in table 4.2 .

Table (4.3) shows that a total of (100) adult Sudanese were selected, whom present (10-55 mm with 25.46±6.764 mm mean of pancreas head), (14-82 mm with 45.61±15.336 mm mean of pancreas body), and (15-88 mm with 44.02±16.686 mm mean pancreas tail).

T-test results will tell us if the mean size and CT No. of pancreas (head, body and tail) for the two groups were statistically different (significantly different) or they were relatively the same.

We can see that the male and female means for (Head CT No. and Head), (Body CT No. and Body) and (Tail CT No. and Body CT No.) are statistically, non-significantly different because the all values of P-values in "Sig. (2-tailed) are more than 0.05. Looking at the Distributions of two groups table (4.4) above, we can conclude that there is no statistically significant difference between the pancreas (head, body and tail) mean for males and females.

Table (4.7) shows the results of (1-Way ANOVA) test for differences between subjects (age groups) in mean pancreas size as in table (4.6). which determine if the different age groups were relatively have the same pancreas size or if they were significantly different from one another. The Sig. value for head, tail and their CT No. are more than 0.05, and we can conclude that the differences in pancreas's heads and tails with respect to age are likely due to chance and they are relatively the same for different age groups, while the differences in pancreas's

body and its CT No. depend on age, since the Sig. values are less than 0.05, therefore, pancreas's body size and its CT No are different for different age groups.

As the age increased the pancreas head, body and tail texture were decreased. 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).

5.2 Conclusion:

The pancreas measurements and texture in Sudanese population with depended to the age and non significantly different with gander .

5.3 Recommendation:

Future studies in evolution of pancreas measurement should be done with larger sample of population for more accurate results.

Future studies should be done with several body characteristic in correlation with pancreas measurements.

Future studies should be done use another modality such as MRI &US .

Future studiesshould be done evolution of pancreas measurements in child.

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Sudan University of science and technology

Collage of Graduate Studies

Data collection sheet of Measurement of Pancreas in Sudanese Population Using Computerized Tomography

NO.	Age	Gender	Pancreas measurement					
			H.CT NO	Head size	Body size	B.CT NO	Tail size	T.CT NO
1.								
2.								
3.								
4.								
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