بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Measurement of Normal Common Bile Duct Diameter using Ultrasonography

قياس القطر الطبيعي للقناه الصفراويه المشتركه بإستخدام التصوير بالموجات فوق الصوتية

A thesis submitted for Partial Fulfillment of the Degree of Master in Medical Diagnostic Ultrasound

By:

Haram Khlil Mohammed Ahmed

Supervisor:

Dr. Babiker Abd-Alwahab Awad Allah Awad Alseed

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الآية

**قال تعالى : ((*أَوَلَيْسَ الَّذِي خَلَقَ السَّمَاوَاتِ وَالأَرْضَ بِقَادِرٍ*
عَلَى أَنْ يَخْلُقَ مِثْلَهُم بَلَى وَهُوَ الْخَلاَّقُ الْعَلِيمُ **{81}** ***إِنَّمَا أَمْرُهُ***
إِذَا أَرَادَ شَيْئًا أَنْ يَقُولَ لَهُ كُنْ فَيَكُون **{82}** ***فَسُبْحَانَ الَّذِي بِيَدِهِ***
مَلَكُوتُ كُلِّ شَيْءٍ وَإِلَيْهِ تُرْجَعُونَ **{83}))**

صدق الله العظيم

سورة يـــس

Dedication

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, ***Khlil and Hanan*** whose words of encouragement and push for tenacity ring in my ears. My sisters ***Suzan, Reem*** and ***Sit nor*** my brothers **(*Safwan and Kamel*)** whose have never left my side and are very special.

I also dedicate this dissertation to my ***many friends*** who have supported me throughout the process. I will always appreciate all they have done,

I dedicate this work and give special thanks to my best friend ***Mohammed*** and my wonderful daughter ***Eslam*** for being there for me throughout the entire program. Both of you have been my ***best cheerleaders***.

To my Mon Amour…

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I owe to the working team in *Dar Elalaj Hospital* for their help during the process of collection of data.

Abstract:

Retrospective study of measurement of common bile duct diameter by ultrasound conducted in Khartoum state, Sudan. In Dar Elelaj hospital from November 2016 to February 2017 the problem of the study was the various factors that affect the diameter of the common bile duct the study aim was measurement of the normal common bile duct using Ultrasonography.

The data was collected from 64 patients classified and analyzed by SPSS (statistical package for the social science).

The study found that there was linear relation between the common bile duct diameter and age, and there was no significant relation between the common bile duct diameter and body mass index and anthropometry.

Study recommended that further studies for measurement of the common bile duct in different locations and posture.

مستخلص البحث:.

هـذه الدراسـه المرجعيـة تمـت فـي عـدد 64 عينـه فـي الفتـره مـن نـوفمبر 2016 الـي فبرايـر 2017 وتكمـن مشـكله الدراسـه فـي العوامـل التـي تـؤثر علـي القيـاس الطبيعـي لقطـر القنـاه الصـفراويه المشـتركه هـدفت الدراسـه الـي تحديـد المـدي الطبيعـي لقطـر القنـاه الصـفراويه المشـتركه, تـم جمـع البيانـات فـي مستشـفي دار العـلاج التخصصـي وتـم تصـنيفها وتحليلهـا بواسـطه برنـامج الحزمـه الاحصائيه للعلوم الاجتماعيه.

وجـدت الدراسـه ان هنالـك علاقـه ذات دلالـه حصـائيه بـين التقـدم فـي العمـر وقطـر القنـاه الصـفراويه المشـتركه وخلصـت ان لـيس هنالـك علاقـه بـين قطـر القنـاه الصـفراوبه المشـتركه ومؤشـر كتلـه الجسـم والقياسات البشريه الاخري .

اوصـت الدراسـه ان يـتم قيـاس قطـر القنـاه الصـفراويه المشـتركه فـي امـاكن مختلفـه بوضـعيات جسـديه مختلفه

List of contents

List of Tables:

List of Figures

List of abbreviations

1	**ALP**	Alkaline Phosphate Level
2	**CT**	Computed Tomography
3	**CBD**	Common Bile Duct
4	**CHD**	Common Hepatic Duct
5	**ERCP**	Endoscopic Retrograde cholangiopancreaticography
6	**FANA**	Fluroscent Antinuclear Antibody
7	**MRI**	Magnetic Resonance Imaging
8	**PBC**	Primary Biliary Cholangitis
9	**PSC**	Primary Scleroting Cholangitis
10	**PTC**	Percutaneous Transhepatic cholangiography
11	**RAD**	Right anterior duct
12	**RPD**	Right posterior duct
13	**US**	Ultrasound
14	**XGC**	Xanthogranulomtous cholecystitis

Chapter one
Introduction

1. Introduction:

The size of the common bile duct is a predictor of biliary obstruction and its measurement is therefore an important component in the evaluation of the biliary system. Availability of normal measurements of the common bile duct would help to distinguish obstructive from non-obstructive causes of jaundice. Ultrasonography is an accurate, safe, non-invasive and inexpensive imaging modality, which is highly sensitive and specific for the detection of many biliary tree diseases. (Freitas, 2006)

Ultrasonography is comparable in accuracy to oral cholecystography, radionuclide studies, computed tomography and magnetic resonance imaging, and more cost-effective ·With the development of high resolution scanners, the luminal diameters of the common bile duct can be assessed accurately. The normal internal diameter of the common bile duct on ultrasonography is 6 mm Different opinions regarding the size of the common bile duct have been revealed in literature. Study done by DaradkehS, Tarawneh E and Al-Hadidy A in Jordan university hospital diameter found to be significantly affecting the diameter of the common bile duct ($P<0.05$) were age, previous cholecystectomy and body mass index. Another study done in Department of Radiology, Addis Ababa University, Medical Faculty, Addis Ababa, Ethiopia by Admassie D the result found to be the mean diameter of the common bile duct diameter was found to be 3.9 mm; measured diameter ranged from 2.1 to 6mm. There was also a positive correlation between the common bile duct diameter with age and weight. No significant difference was noted between the two sexes and common bile duct diameter. No association was observed with height and common bile duct diameter (mittal R, 2010)

It is an established fact that variations exist in the anthropometric features of various populations and regions Studies have suggested correlation between different kinds of body builds and diseases. However, despite technological advancements, the association of anthropometric measurements with the diameters of common bile duct has remained controversial (mittal R,2010)

1.2 Problem of the study:

Changes in caliber of the CBD related to various factors including hepatobiliary disease this study tries to assess the range of normal measurements in relation with age, sex and anthropometry.

1.3 Objectives:

1.3.1 General objective:

The aim of this study is measurement of normal Common Bile Duct Diameter and its Correlation with Age, Sex and Anthropometryinorder to determine the range of normal diameters for common bile duct among this population.

1.3.2 Specific objectives:

- To determine the association of CBD diameter with age.
- To determine the association of CBD diameter with sex.
- To determine the association of CBD diameter with physical measurements (height, weight, chest circumference, circumference at the umbilicus).

Chapter Two

2. Anatomy and normal variant:

The biliary tract is the conduit between the liver and the duodenum and is designed to store and transport bile, under control of neuronal and hormonal regulation. Bile is formed in the hepatocytes and steadily secreted into canaliculi, which transport it to the larger extrahepatic ducts. The sphincter of Oddi regulates the flow of bile into the duodenum or to the cystic duct and the gallbladder. When stimulated, the gall-bladder contracts steadily, the sphincter relaxes and bile flow into the duodenum increases (Bonheur, 2016)

2.1 Bile Ducts:

The tubes that carry bile through the liver and gallbladder are known as bile ducts and form a branched structure known as the biliary tree. Bile produced by liver cells drains into microscopic canals known as bile canaliculi. The countless bile canaliculi join together into many larger bile ducts found throughout the liver. These bile ducts next join to form the larger left and right hepatic ducts, which carry bile from the left and right lobes of the liver Those two hepatic ducts join to form the common hepatic duct that drains all bile away from the liver. The common hepatic duct finally joins with the cystic duct from the gallbladder to form the common bile duct, carrying bile to the duodenum of the small intestine. Most of the bile produced by the liver is pushed back up the cystic duct by peristalsis to arrive in the gallbladder for storage, until it is needed for digestion. (Bonheur, 2016)

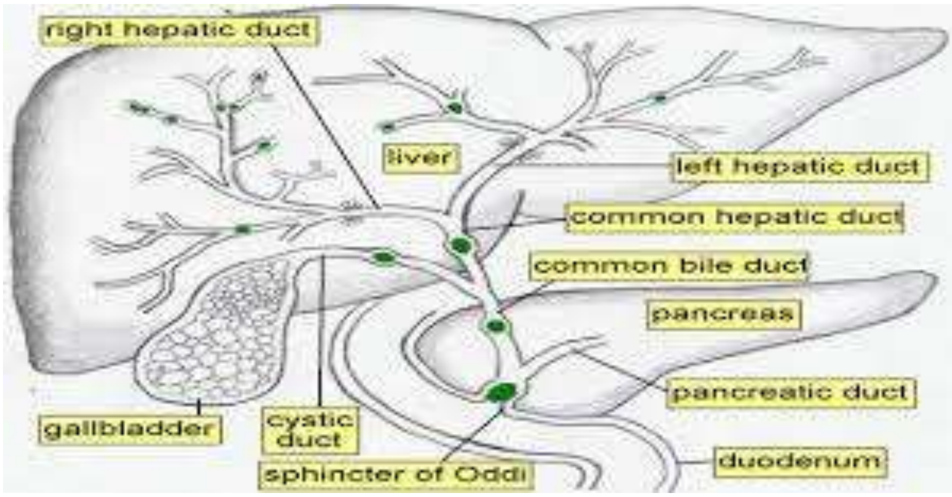

Figure (2.1): shows liver anatomy (Awayne, 2012)

An understanding of the normal location of the bile ducts and common anatomic variations is important in staging of malignancies and directing intervention. In biliary terminology, proximal denotes the portion of the biliary tree that is in relative proximity to the liver and hepatocytes, whereas distal refers to the caudal end closer to the bowel. The term branching order applies to the level of division of the bile ducts starting from the common hepatic duct (CHD); first-order branches are the right and left hepatic ducts, second-order branches are their respective divisions (also known as secondary biliary radicles), and so on. Central specifies proximity to the porta hepatis, whereas peripheral refers to the higher-order branches of the intrahepatic biliary tree extending well into the hepatic parenchyma. Knowledge of Couinaud's functional anatomy of the liver is also vital in description of the intrahepatic biliary abnormalities. The intrahepatic ducts are not in a fixed relation to the portal veins within the portal triads and can be anterior or posterior to the vein or even tortuous about the vein. The right and left hepatic ducts, that is, the first-order branches of the CHD, are routinely seen on sonography, and normal second-order branches may be visualized .The use of spectral and color Doppler ultrasound is often needed to distinguish hepatic arteries from ducts. In our experience, visualization of third-order or higher-order branches is often an abnormal finding and requires a search for the cause of dilation. Most of the right and left hepatic ducts are extrahepatic and, along with the CHD, form the hilar or central portion of the biliary tree at the porta hepatis.This is the most common location for cholangiocarcinoma. The normal diameter of the first-order and higher-order branches of the CHD has been suggested to be 2 mm or less, and no more than 40% of the diameter of the adjacent portal vein.The most common branching pattern of the biliary tree occurs in 56% to 58% of the population On the right side, the right hepatic duct forms from the right anterior and right posterior branches, draining the anterior (segments 5 and 8) and posterior (segments 6 and 7) segments of the right lobe of the liver, respectively. On the left side, segment 2 and 3 branches join to the left of the falciform ligament to form the left hepatic duct. This duct becomes extrahepatic in location as it extends to the right of the falciform ligament, where it is joined by ducts of segments 4 and 1.The key to understanding the common normal variants of biliary branching lies in the variability of the site of insertion of the right posterior duct (RPD) (segments6 and 7). The RPD often extends centrally toward the porta hepatis in a cranial direction. It passes superior and posterior to the right anterior duct (RAD) and then turns caudally, joining the RAD to form the short right hepatic duct .Three other common sites of insertion of the RPD account for the majority of the anatomic variations. If the RPD extends more to the left than usual, it can join the junction of the right and left hepatic ducts (“trifurcation pattern”; ~8% of normal variants) or the left hepatic duct (~13%)If the RPD extends in a caudal-medial direction instead, it can join the CHD or common bile duct (CBD) directly (~5%). Anomalous drainage of various segmental hepatic ducts directly into the common hepatic ducts is less common.(Carol M.2011) .

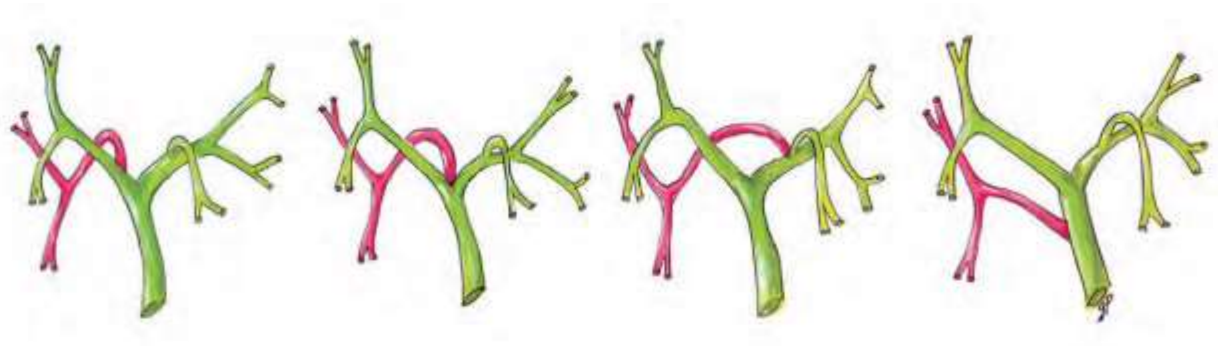

Figure (2.2): Common variants of bile duct branching, (Carol M.2011).

2.2 physiology

Bile is produced by the liver and is channeled by the biliary ductal system into the intestinal tract for the emulsification and absorption of fats. Biliary disease is caused by abnormalities in bile composition, biliary anatomy, or function. The liver determines the chemical composition of bile, and this may be modified later by the gallbladder and the biliary epithelium. Cholesterol, ordinarily insoluble in water, comes into solution by forming vesicles with phospholipids (principally lecithin) or mixed micelles with bile salts and phospholipids. (Bonheur, 2016)

When the ratio of cholesterol, phospholipids, and bile salts is outside an optimum range, cholesterol monohydrate crystals may come out of solution from multi lamellar vesicles. Cholesterol super saturation of bile appears to be a prerequisite for gallstone formation, which involves a variety of factors that affect the activity of low-density lipoprotein (LDL) uptake, hepatic 3-methylglutaryl coenzyme A reductase (HMG CoA), acyl cholesterol-lecithin acyltransferase, and 7-alpha hydroxylase. (Bonheur, 2016)

By itself, cholesterol supersaturation is inadequate for explaining gallstone pathogenesis. Nucleation, the initial step in gallstone formation, is the transition of cholesterol from a soluble state into a solid crystalline form. Within the gallbladder bile, biologic molecules influence the process in a positive or negative fashion.For example, mucus may function to promote nucleation, whereas bile-specific glycoproteins may function to inhibit nucleation. Mucin hypersecretion by the gallbladder mucosa creates a viscoelastic gel that fosters nucleation. Arachidonyl lecithin, which is absorbed from the alimentary tract and secreted into the bile, stimulates prostanoid synthesis by gallbladder mucosa and promotes mucus hypersecretion, while inhibitors of prostaglandin inhibit mucus secretion.Finally, gallbladder hypomotility and bile stasis appear to promote gallstone formation and growth, which may be important in diabetes, pregnancy, oral contraceptive use in women, and prolonged fasting in critically ill patients on total parenteral nutrition(Bonheur,2016)

2.3 Pathology:

2.3.1 Gallstones:

In about 80% of patients, gallstones are clinically silent. Approximately 20% of patients develop symptoms over 15-20 years, that is, about 1% per year, and almost all become symptomatic before complications develop. Biliary-type pain, the typical clinical presentation, is due to obstruction of the bile duct lumen. The predictive value of other complaints (eg, intolerance to fatty food, indigestion) is too low to be clinically helpful. The incidence of gallbladder cancer developing in the setting of cholelithiasis is low, about 0.1% per year. Two main types of gallstones exist (Bonheur,2016)

→***Cholesterol stones (85%)*** These are divided into 2 subtypes—pure (90-100% cholesterol) or mixed (50-90% cholesterol).Pure stones often are solitary, whitish, and larger than 2.5 cm in diameter. Mixed stones usually are smaller, multiple in number, and occur in various shapes and colors. They tend to be arranged in laminated layers of an alternating thicker whitish cholesterol and a thinner dark pigment in a concentric pattern around a pigmented center (similar to the rings visible on the cross section of a tree). These stones tend to occur in residents of Western countries, and they usually are found in the gallbladder The risk factors associated with the development of cholesterol gallstones include (obesity, a high calorie diet, clofibrate therapy, gastrointestinal disorders involving major malabsorption of bile acids, cystic fibrosis with pancreatic insufficiency, and female sex and the use of oral contraceptives and other estrogenic medications. Coffee and ascorbic acid have been shown to reduce the risk of symptomatic cholesterol gallstones). (Bonheur, 2016)

→***Pigment stones (15%)*** Pigment stones occur in 2 subtypes—brown and black.Brown stones are made up of calcium bilirubinate and calcium-soaps. Bacteria are involved in their formation via secretion of beta glucuronidase and phospholipase. The bacterial glycocalyx aggregates with the bile pigment and precipitates out of solution. These stones are more common in Asia and tend to form within the bile ducts. They frequently are associated with periampullary duodenal diverticula.Black stones typically form in the gallbladder and result when excess bilirubin enters the bile and polymerizes into calcium bilirubinate. These stones are more common in patients with chronic hemolysis, alcoholic cirrhosis, and advanced age.

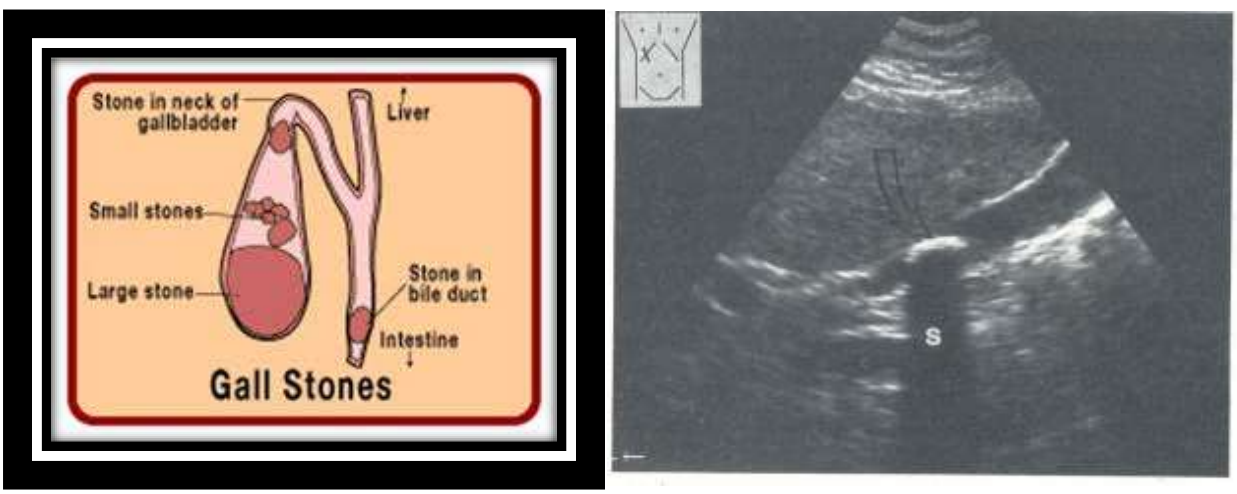

Figure (2.3): Gall bladder stone demonstrate posterior acoustic shadowing(Jane,1999).

2.3.2 Choledocholithiasis:

Choledocholithiasis is the presence of at least one gallstone in the common bile duct. The stone may be made up of bile pigments or calcium and cholesterol salts (Jane, 1999).

Figure (2.4): Choledocholithiasis (Jane,1999).

2.3.3 Cholecystitis:

Is inflammation of the gallbladder. Symptoms include right upper abdominal pain, nausea, vomiting, and occasionally fever. Often gallbladder attacks (biliary colic) precede acute cholecystitis. The pain lasts longer in cholecystitis than in a typical gallbladder attack. Without appropriate treatment, recurrent episodes of cholecystitis are common. Complications of acute cholecystitis include gallstone pancreatitis, common bile duct stones, or inflammation of the common bile duct

divide into: acute and chronic cholecystitis ,and according to its association with stone it sub divide into acute calculus cholecystitis or acute acalculus cholecystitis.

2.3.3.1 Acute calculous cholecystitis:

Gallstones blocking the flow of bile account for 90% of cases of cholecystitis (acute calculous cholecystitis). Blockage of bile flow leads to thickening and buildup of bile causing an enlarged, red, and tense gallbladder. The gallbladder is initially sterile but often becomes infected by bacteria, predominantly E. coli, Klebsiella, Streptococcus, and Clostridium species. Inflammation can spread to the outer covering of the gallbladder and surrounding structures such as the diaphragm, causing referred right shoulder pain.(Greenberger N.et al 2012).

2.3.3.2 Acalculous cholecystitis:

In acalculous cholecystitis, no stone is in the biliary ducts. It accounts for 5–10% of all cases of cholecystitis and is associated with high morbidity and mortality rates. Acalculous cholecystitis is typically seen in people who are hospitalized and critically ill. Males are more likely to develop acute cholecystitis following surgery in the absence of trauma. It is associated with many causes including vasculitis, chemotherapy, major trauma or burns. The presentation of acalculous cholecystitis is similar to calculous cholecystitis. Patients are more likely to have yellowing of the skin (jaundice) than in calculous cholecystitis. Ultrasonography or computed tomography often shows an immobile, enlarged gallbladder. Treatment involves immediate antibiotics and cholecystectomy within 24–72 hours.(Butler et al 2015)

Figure (2.5): Classic appearance acute calculus cholecystitis.(Carol M.2011)

Figure (2.6): Classic appearance of acute acalculus cholecystitis(Carol M.2011).

2.3.4 Mirizzi syndrome:

Mirizzi syndrome refers to common hepatic duct obstruction caused by an extrinsic compression from an impacted stone in the cystic duct. It has been estimated to occur in 0.7-1.4% of all cholecystectomies. It is often not recognized preoperatively, which can lead to significant morbidity and biliary injury, particularly with laparoscopic surgery *(R* Umashanke*r 2016)*

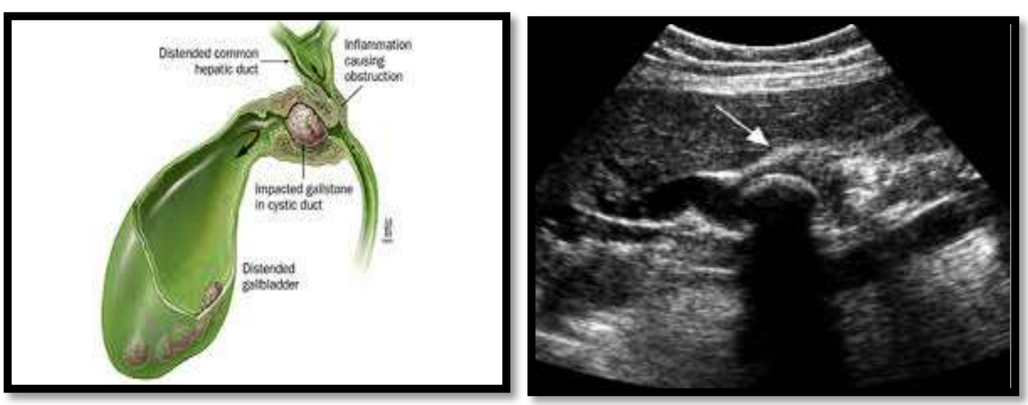

Figure (2.7): Mirizzi syndrome sagittal sonogram shows a dilated common bile duct obstructed by a large stone impacted in the distal cystic duct. This appearance may be mistaken for a common bile duct stone. (Carol M,2011)

2.3.5 Chronic cholecystitis:

Chronic cholecystitis occurs after repeated episodes of acute cholecystitis and is almost always due to gallstones. Chronic cholecystitis may be asymptomatic, may present as a more severe case of acute cholecystitis, or may lead to a number of complications such as gangrene, perforation, or fistula formation. Xanthogranulomatous cholecystitis (XGC) is a rare form of chronic cholecystitis which mimics gallbladder cancer although it is not cancerous. It was first reported in the medical literature in 1976 by McCoy and colleagues.(Rao RV et al ,2005)

Figure (2.8): shows chronic cholecystitis (indianradiologist,2015)

2.3.6 Cholangitis:

Cholangitis is an infection of the biliary system, complicating benign and malignant obstruction of the biliary tract. The clinical presentation is quite variable depending on the nature of the illness, patient age, and condition of the patient. Charcot triad (ie, fever, right upper quadrant pain, jaundice) occurs in only 20-70% of cases. Hypotension and mental status changes also may accompany severe infection, a pentad described by Reynolds in 1959. The organisms typically identified are enteric in origin, notably Escherichia coli, Streptococcus faecalis, Clostridium species, Klebsiella *species*, Enterobacter *species*, Pseudomona s *specis*, and *Proteus* species. They probably enter the biliary system via portal bacteremia. No correlation exists between the severity of clinical manifestations and the presence or absence of pus in the biliary system; however, suppurative cholangitis is associated with a higher mortality rate (David S 2010).

Figure (2.9): Cholangitis (Carol M,2011).

2.3.7 Recurrent pyogenic cholangitis:

Recurrent pyogenic cholangitis, also known as "oriental cholangiohepatitis," is prevalent in several parts of Asia and the Pacific Rim countries. It is limited to Asian immigrants in America, occurs in the second to fourth decades of life, and is associated with a lower socioeconomic class. It is initiated by parasitic infestation of the biliary ducts by Opisthorchis sinensis (formerly Clonorchis sinensis), in which the adult fluke may impair bile flow. In the setting of bile stasis and secondary bacterial infection, pigment stones form around ova and sets the stage for the intermittent obstruction leading to recurrent pyogenic cholangitis. Pathologic changes principally affect the intrahepatic bile ducts (curiously, more often the left duct). (David S 2010).

Figure (2.10): shows Recurrent pyogenic cholangitis (Carol M.2011).

2.3.8 Primary sclerosing cholangitis:

PSC is a chronic cholestatic biliary disease characterized by non suppurative inflammation and fibrosis of the biliary ductal system. The cause is unknown but is associated with autoimmune inflammatory diseases, such as chronic ulcerative colitis and Crohn colitis (less commonly), and rare conditions, such as Riedel thyroiditis and retroperitoneal fibrosis. Most patients present with fatigue and pruritus and, occasionally, jaundice. The natural history is variable but involves progressive destruction of the bile ducts, leading to cirrhosis and liver failure. The clinical features of cholangitis (ie, fever, right upper quadrant pain, jaundice) are uncommon unless the biliary system has been instrumented. (David S 2010).

Figure (2.11): shows Primary sclerosing cholangitis (Berg CP, 2009).

2.3.9 Autoimmune cholangitis:

represents a rare, distinct disease entity., the levels of gamma globulin and IgM are lower, and the results of tests for fluorescent antinuclear antibody (FANA) and anti–smooth muscle antibody are positive more commonly .(Berg CP, 2009).

2.3.10 Neoplasms of the biliary tract:

Carcinoma of the biliary system manifests with clinical symptoms of weight loss (77%), nausea (60%), anorexia (56%), abdominal pain (56%), fatigue (63%), pruritus (51%), fever (21%), malaise (19%), diarrhea (19%), constipation (16%), and abdominal fullness (16%). Symptomatic patients usually have advanced disease, with spread to hilar lymph nodes before obstructive jaundice occurs. It is associated with a poor prognosis. (Berg CP, 2009).

2.3.10.1 Gallbladder cancer:

This uncommon malignancy affects 2.5 individuals per 100,000 population. It represents 54% of biliary tract cancers, and more than 6500 patients die from this disease in the United States each year. Cancer that develops in the infundibulum can produce hydrops of the gallbladder that is clinically indistinguishable from an obstructing stone. (Berg CP, 2009).

Figure (2.12): shows gall bladder carcinoma (Radiopaedia, 2016).

2.3.10.2 Cholangiocarcinoma:

Cholangiocarcinoma is an adenocarcinoma of the bile ducts.It may occur without associated risk factors, but it is associated more commonly with chronic cholestatic liver disease such as PSC, choledochal cysts, oriental cholangiohepatitis, and work-related handling of asbestos. Cholangiocarcinoma accounts for 25% of biliary tract cancers. Patients usually present with jaundice, a vague upper or right upper quadrant abdominal pain associated with anorexia, weight loss, and pruritus. (Cavallaro A, 2009)

Figure (2.13): shows cholangiocarcinoma (Ultrasound cases, ID 21207ipg)

2.3.11 Biliary tract cysts:

Cystic dilatation of the biliary tree is an uncommon abnormality. About half of the patients present with some combination of jaundice, abdominal pain, and an abdominal mass. The presence of these cysts is often associated with anomalous union of the pancreatic and biliary ductal system. This suggests that pancreatic juice enters the bile duct, causes a proteolytic and inflammatory injury to the duct wall, and leads to biliary cyst formation. The most commonly used classification scheme was proposed by Todani, which defines 5 cyst types, with groups I and IV having subtypes.Type I: cystic dilatation of the extrahepatic bile duct with normal intrahepatic bile ducts (most common - 70 to 80%) ,Type II: diverticulum of the common bile duct (rare) ,Type III: intrapancreatic diverticulum of the distal common bile duct or choledococele (rare) ,Type IV: cystic dilatation of the extrahepatic and intrahepatic bile ducts (second most common form). ,Type V: cystic dilatation of the intrahepatic bile ducts with normal extrahepatic bile duct (also called Caroli’s disease) ,Form fruste: combines dilatations of both intra- and extrahepatic ducts. (Magdalena et al, 2000).

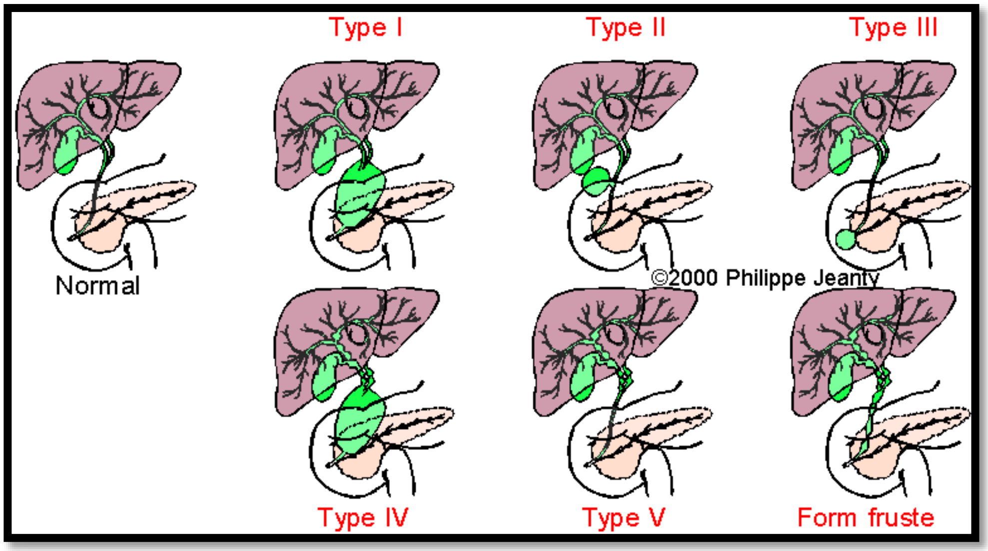

Figure (2.14): shows biliary tract cysts types (Magdalena et al, 2000).

2.3.12 AIDS Cholangiopathy:

Cholestasis can be seen in AIDS as a result of biliary ductal changes seen on a cholangiogram that resemble primary sclerosing cholangitis. The ductal strictures are believed to be caused by infections, including Cryptosporidium, cytomegalovirus, microsporidian, and Cyclosporine. (Lefkowitch JH, 1997)

Patients present with right upper quadrant pain and laboratory tests suggesting Cholestasis. A wide variety of other hepato biliary abnormalities may also occur in those with HIV infection, including granulomatous liver disease from mycobacterium, fungi, or drugs, bacterial abscesses, neoplasm such as Kaposi's sarcoma or lymphoma, and drug toxicity. Initial evaluation should include ultrasound and ERCP if the ultrasound is abnormal .ERCP should also be carried out despite a normal ultrasound if there is evidence of severe abdominal pain. Endoscopic therapy is useful in certain circumstances. Endoscopic sphincterotomy is useful for those patients with symptoms of papillary stenosis (e.g., abdominal pain, jaundice, cholangitis). Endoscopic stenting of the dominant structure of the biliary may also be helpful.(Daly CA, 1996)

2.3.13 Parasites

Extrahepatic biliary obstruction has been seen with various parasitic infections, such as Strongyloides and Ascaris spp, and liver flukes, such as Opisthorchis sinensis and Fasciola hepatica*(*Daly CA, 1996).

2.4 laboratory tests and Investigations done:

2.4.1 Laboratory tests:

2.4.1.1 Urine bilirubin levels: Urine bilirubin normally is absent. When it is present, only conjugated bilirubin is passed into the urine. This may be evidenced by dark-colored urine seen in patients with obstructive jaundice or jaundice due to hepatocellular injury. However, reagent strips are very sensitive to bilirubin, detecting as little as 0.05 mg/dl. Thus, urine bilirubin may be found even in the absence of hyperbilirubinemia or clinical jaundice. (Bonheur, 2016)

2.4.1.2 Serum bilirubin level: Regardless of the cause of cholestasis, serum bilirubin values (especially direct) are usually elevated. However, the degree of hyper bilirubinemia cannot help reliably distinguish between the causes of obstruction. Extrahepatic obstruction: This is typically associated with considerable direct and indirect bilirubin elevation.,Intrahepatic obstruction*:*Both conjugated and unconjugated bilirubin fractions may increase in varying proportions**.**

2.4.1.3 Alkaline phosphatase (ALP) level :A membrane-bound enzyme localized to the bile canalicular pole of hepatocytes, ALP is markedly elevated in persons with biliary obstruction. However, high levels of this enzyme are not specific to cholestasis. To determine whether the enzyme is likely to be of hepatic origin, measure gamma-glutamyl transpeptidase or 5-prime-nucleotidase. These values tend to parallel the ALP levels in patients with liver disease. GGT is used most commonly. While it is part of the routine evaluation of biliary obstruction, the degree of elevation of ALP cannot be used to reliably discriminate between extrahepatic and intrahepatic causes of biliary obstruction.

2.4.1.4 Prothrombin time: This may be prolonged because of malabsorption of vitamin K. Correction of the PT by parenteral administration of vitamin K may help distinguish hepatocellular failure from cholestasis. Little or no improvement occurs in patients with parenchymal liver disease

2.4.1.5 Antimitochondrial antibody levels: The presence of antimitochondrial antibodies, usually in high titers, is indicative of PBC. They are usually absent in patients with mechanical biliary obstruction or PSC (Bonheur, 2016)

2.4.2 Investigations Done:

2.4.2.1 CT and MRI (MRCP):

Both magnetic resonance (MR) imaging and computed tomographic (CT) cholangiography have the advantages of allowing detailed evaluation of the biliary tract with a large field of view, excellent patient tolerance, and three dimensional (3D) data sets that can be cholangiographically displayed, Both imaging modalities are less likely to cause patient discomfort or injury than is endoscopic retrograde cholangiopancreatography (ERCP), an invasive procedure, and either study may be preferred as an initial noninvasive test if immediate therapy for a known problem is not the primary aim .MR imaging offers the advantages of improved stone conspicuity and absence of ionizing radiation, whereas CT is generally less prone to artifacts. Determination as to whether MR imaging or CT is preferred is based on (among other variables) opinion, local expertise, and the vagaries of technologic advances. The potential impact of the latter variable is illustrated by the fact that the role of 3D respiratory-gated MR imaging, the use of hepatobiliary contrast agents for both MR imaging and CT, and newer multi-detector CT scanners all remain areas of clinical study. However, biliary stones and gallstones are generally better seen at MR imaging than at CT. A solid understanding of biliary disease and of the corresponding radiologic findings is essential to the effective application of any modality. (Bonheur, 2016)

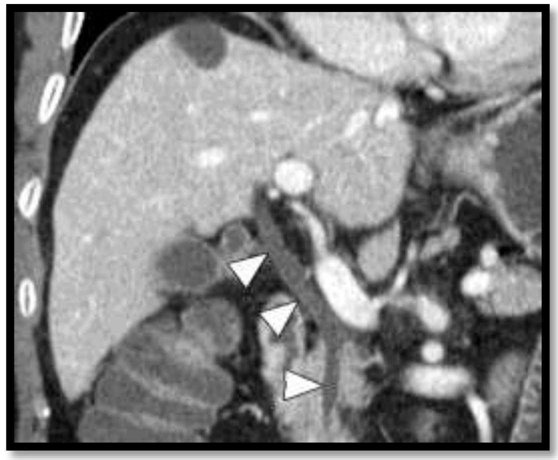

Figure (2.15): shows coronal intravenous contrast-enhanced reformatted image from CT data shows the CBD and CHD (arrowheads), which are normal caliber and have an imperceptible wall. The IBDs are barely visible (Radiopeadia ,2016).

2.4.2.2 Endoscopic Retrograde Cholangio Pancraeticography (ERCP):

An endoscopic retrograde cholangiopancreatogram (ERCP) test checks the tubes (ducts) that drain the liver,gall bladder,and pancreas . A flexible, lighted scope (endoscope) and X-ray pictures are used.The scope is put through the mouth and gently moved down the throat. It goes into the esophagus ,stomach and duodenum until it reaches the point where the ducts from the pancreas and gall bladder drain into the duodenum. X-rays will then be taken.ERCP can treat certain problems found during the test. In some cases the doctor can insert small tools through the scope to: Take a sample of tissue from an abnormal growth. Then it can be checked for problems. Remove a gall stone in the common bile duct. Open a narrowed bile duct. A narrowed bile duct can be opened by inserting a small wire-mesh or plastic tube (called a stent) in the duct.

Figure (2.16): shows normal ERCP (Radiopeadia , 2016).

2.4.2.3 Percutaneous transhepatic cholangiography

Percutaneous transhepatic cholangiography (**PTHC** or **PTC**) or percutaneous hepatic cholangiogram**:** is a radiologic technique used to visualize the anatomy of the biliary tract. A contrast medium is injected into a bile duct in the liver, after which X-rays are taken. It allows access to the biliary tree in cases where (ERCP) has been unsuccessful.

Figure (2.17): shows normal PTC (Radiopeadia , 2016).

2.4.2.4 Oral Cholecystogram:

Oral cholecystogram is an X-ray examination of the gallbladder,Oral” refers to the oral medication you take before the test. The medication is an iodine-based contrast agent that makes your gallbladder more clearly visible on the X-ray. The oral cholecystogram study is used to diagnose problems related to the gallbladder. The X-ray can show inflammation of the organ, and other abnormalities like polyps, tumors, and gallstones.

Figure (2.18): shows normal oral cholecystogram(Radiopeadia ,2016).

2.4.2.5 T-tube Cholangiography:

Cholangiography is the x-ray examination of the bile ducts (biliary tract) after administration of a contrast dye to delineate these channels on the images. The procedure may be performed either during gallbladder removal surgery (operative cholangiography) or postoperatively (T-tube cholangiography).Operative cholangiography involves injecting the contrast dye directly into the common bile duct during open surgery. X-ray films are then used to guide the surgeon and to identify any stones or other obstructions for immediate removal.T-tube cholangiography is typically performed 5 to 10 days after gallbladder removal. Contrast dye is injected through a T-shaped rubber tube placed in the common bile duct during surgery, and x-rays are then taken to detect any residual stones or other abnormalities. (Bonheur, 2016)

2.4.2.6 Cholescintigraphy

Cholescintigraphy or hepatobiliary scintigraphy is scintigraphy of the hepatobiliary tract including the gall bladder and bile ducts. The image produced by this type of medical imaging, called a cholescintigram, is also known by other names depending on which radiotracer is used, such as HIDA scan, PIPIDA scan, DISIDA scan, or BrIDA scan. Cholescintigraphic scanning is a nuclear medicine procedure to evaluate the health and function of the gallbladder and biliary system. A radioactive tracer is injected through any accessible vein, and then allowed to circulate to the liver, where it is excreted into the bile ducts and stored by the gall bladder until released into the duodenum.

In the absence of gall bladder disaese, the gallbladder is visualized within 1 hour of the injection of the radioactive tracer. If the gallbladder is not visualized within 4 hours after the injection, this indicates either cholecystitis or cystic duct obstruction, such as by cholelithiasis. (Bonheur, 2016)

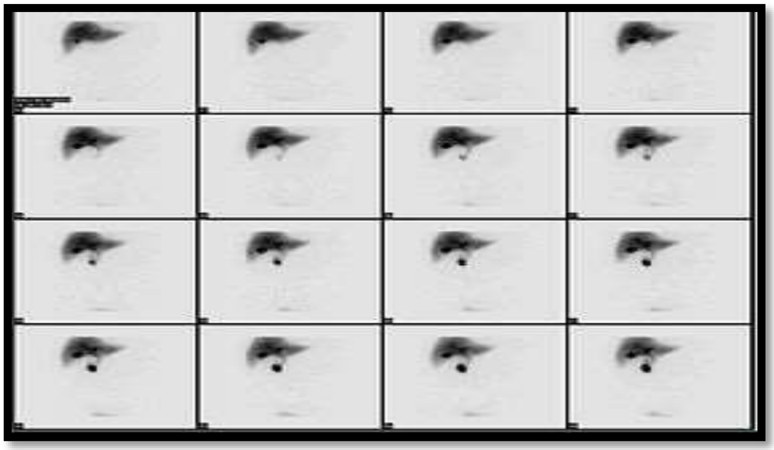

Figure (2.19): Normal hepatobiliary scan HIDA scan(Wikipeadia,2016).

2.4.2.7 Ultrasound (U/S):

Ultrasound relies upon the transmission of targeted sound waves of varying selected frequencies through tissues, with subsequent computerized conversion of the signals from the reflected waves into anatomical images on a screen. The degree of reflection of sound waves depends upon the interface between tissues with different acoustic properties. The degree of echogenicity depends upon the ability of the tissue being evaluated to reflect or absorb the ultrasound waves. Thus, a fatty liver will attenuate the ultrasound beam somewhat, limiting full evaluation of the liver parenchyma. Similarly, waves are not transmitted through air.

Normal measurements on ultrasound: Measurements of components of the hepatobiliary tree depend upon the skill of the ultrasonographer obtaining the measurements, and there is variability in terms of what is considered "normal." However, some general estimates are available regarding the expected sizes of structures in the hepatobiliary tree(ultrasoundpeadia,2007).

2.4.2.7.1 Positioning and technique:

Imaging approach:

Trans abdominal ultrasound is an ideal initial investigation for suspected biliary and GB pathology, supplemented by various imaging modalities include MR/MRCP/and CT/US plays a key role in the multimodality evaluation of complex biliary problems.(Ahuja 2007)

Imaging protocol:

Patient should be fasted at least 4 hours prior to US examination.

Sonographic evaluation of the bile ducts should include the following five images

- a subcostal oblique view to assess the ductal confluence anterior to the portal vein bifurcation at the porta hepatis;
- a transverse left lobe view for evaluation of left intrahepatic ducts (recumbent);
- a right coronal intercostal view for evaluation of the right intrahepatic ducts;
- a hepatoduodenal ligament view for assessment of the extrahepatic duct from the common hepatic duct to the pancreas head; and
- Views of the pancreas head to assess the distal common bile duct.

Figure (2.20): Diagram showing the scanning areas used to obtain each of the five basic images (Harlad .1995)

Figure (2.21): Image show the normal appearance of the common bile duct in relation with portal vein (Harlad, 1995).

2.5 Previous study:

Study done by **Nidhi Lal in December 2014** to obtain data on sonographically measured diameters of common bile duct in series of normal Rajasthani population and to measure its correlation with age ,sex and anthropometry. the study include 200 participants with equal proportion belonging to either sex .CBD measured at three location at the porta hepatis .in the most distal aspect of the head of pancreas and mid-way between these points. Anthropometric measurements including height, weight .chest circumference, circumference at the transpyloric plane, circumference at umbilicus and circumference at the hip were obtained using standard procedure, the results revealed that Mean age of study subjects was 34.5 years (Range 18-85 years). Mean diameters of the common bile duct in the three locations were: proximal, 4.0 mm (SD 1.02 mm); middle, 4.1 mm (SD 1.01 mm); and distal, 4.2 mm (SD 1.01 mm) and overall mean for all measures 4.1 mm (SD 1.01 mm). Aerage diameter ranged from 2.0 mm to 7.9 mm, with 95 percent of the subjects having a diameter of less than 6 mm. We observed a statistically significant relation of common bile duct with age, along with a linear trend. There was no statistically significant difference in common bile duct diameter between male and female subjects. The diameter did not show any statistically significant correlation with any of the anthropometric measurements.

Another study done by **Perret R** aimed to evaluate the Common bile duct measurements in an elderly population done in 1,018 patients between the ages of 60 to 96 periods to determine if there is a significant change in its size with aging. All of the patients included in the study were being evaluated primarily for carotid or peripheral vascular disease. Any patients with a history of biliary disease (i.e. bilirubin level greater than 1.5 mg/ml, cholecystectomy, or cholelithiasis) were excluded. Ultrasonography of the common bile duct was performed only in those patients with no subjective abdominal pain or icterus. Our results demonstrated a small although statistically significant increase in the caliber of the common bile duct with increasing age (60 years old or less, mean diameter 3.6 mm +/- 0.2mm, versus over 85 years old, mean diameter 4 mm +/- 0.2 mm, P = 0.009). Although the common bile duct did increase in size with aging, 98% of all ducts remained below 6 to 7 mm, the commonly accepted upper range of normal.

Another study done in **November 2005 by Daradkeh S** The purpose of the study was to see the effect of age, sex, body mass index, previous cholecystectomy, hepatomegaly and fasting status on the common bile duct diameter.A series of 463 patients, 283 females and 180 males, with no hepatobiliary or pancreatic pathology were included in this study, the mean age was 45 +/- 16 years. Their age, sex, weight, height, fasting status and previous cholecystectomy was assessed and recorded by a physician prior to ultrasound examination. All patients were examined by real-time ultrasound to see if there was any pathology in the hepatobiliary and pancreatic area. Those with history of common bile duct exploration, endoscopic sphincterotomy or with previous history of cholecystectomy of less than 6 months and patients with common bile duct pathology were excluded from the study. The mid portion of the common bile duct was taken as a fixed measurement for all patients and the size of the liver was also recorded.result showed that the factors found to be significantly affecting the diameter of the common bile duct were age, previous cholecystectomy and body mass index.If the CBD dilatation cannot be explained by age, previous cholecystectomy and BMI, a pathology causing obstruction should be ruled out.

Chapter Three

3. Material and methods

3.1 Materials:

This retrospective crossectional study aimed to measure the normal diameter of the common bile duct. The data used in this study was collected from Dar Elelaj Khartoum state from November 2016 to January 2017.

3.1.1 Subjects:

Study cases were 64(32female and 32male)all were normal subject came for the ultrasound department for routine scan ,all subjects have liver ,biliary ,pancreatic disease and pregnant ladies were excluded from the study, Common bile duct was measured at its association with the portal vein in the long axis of the gallbladder. Anthropometric measurements including height, weight, chest circumference, and abdominal circumference at umbilicus were obtained using standard procedures.

3.1.2 Machine used:

All patients where scanned by philips HD7 ultrasound machine using curve linear low frequency transducer (3.5-5 MHz).

Figure (3.1): U/S Philips HD7 machine

3.2 Method

Ultrasound scanning of 64 normal subjects was done by radiologist. Common bile duct internal diameter was measured in millimeters.

3.2.1 Technique used:

The area for evaluation was fixed and skin adequately lubricated to facilitate ultrasound transmission. The transducer was gently applied and longitudinal scan was taken.

3.2.2 Image interpretation:

The scan include sonographic information at the mid clavicular line ,At this location the common bile duct and hepatic artery appear as two smaller circles anterior to the portal vein, giving an appearance of a face with two ears also called a ‘Mickey Mouse’ sign. With the indicator directed toward the patient’s right, the right ear is the common bile duct and the left ear, the hepatic artery.

3.2.3 Data analysis:

It has been carried out by statically package for social sciences SPSS and EXCEL programmes

Chapter Four

4 Results:

This study includes 64 (equal distribution between both sexes) patients aged between 19-90 years all were normal , came to Dar Elelaj hospital for abdominal ultrasound

Table 4.1: show the statistical measurement for the study data

	Minimum	Maximum	Mean	Std. Deviation
Age(years)	19	90	42.97	20.745
Height(cm)	139	180	161.35	9.767
Weight(kg)	48	92	65.14	10.555
BMI	18	32	24.95	2.918
CBD (mm)	2	6	3.31	.789
Chest circum.(cm)	55	114	76.46	14.680
Abd circum.(cm)	62	122	85.97	15.251

Table 4.2: Shows frequency distribution of patient's age

Age (yrs.)	Frequency	Percent
19-39	35	54.7
40-60	13	20.3
61-80	12	18.8
>81	4	6.3

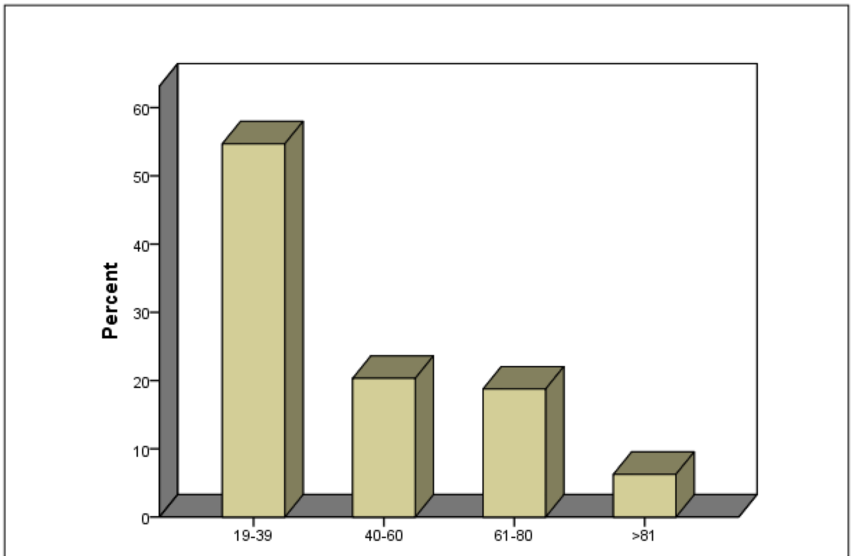

Figure (4.1): show age groups percent.

Table (4.3): Show correlations between variables including (Age,BMI.chest circumference, abdomen circumference

variables	Age(years)	CBD (mm)	BMI	Chest circum.(cm)	Abd circum.(cm)
Age(years)	1	**.635****	.075	.208	.268*
		.000	.556	.099	.032
	64	64	64	64	64
CBD (mm)	**.635****	1	.028	.246*	.265*
	.000		.824	.050	.034
	64	64	64	64	64
BMI	.075	.028	1	.262*	.196
	.556	.824		.036	.121
	64	64	64	64	64
Chest circum.(cm)	.208	.246*	.262*	1	**.904****
	.099	.050	.036		.000
	64	64	64	64	64
Abd circum.(cm)	.268*	.265*	.196	**.904****	1
	.032	.034	.121	.000	
	64	64	64	64	64

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

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

Table (4.4): shows frequency distribution of CBD diameter

CBD diameter(mm)	Frequency	Percent
2	19	29..6
3	30	46.8
4	13	20.3
5	1	1.5
6	1	1.5

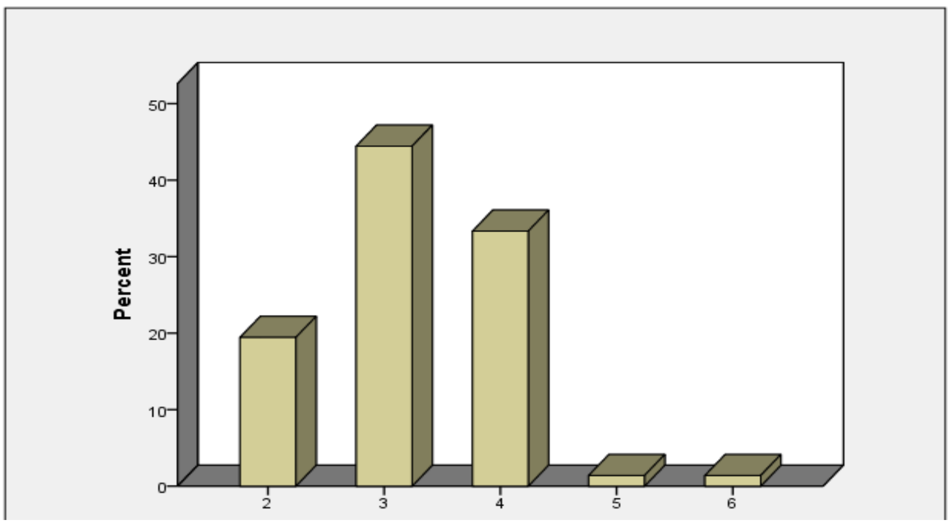

Figure (4.2): show percentage of the CBD diameter.

Table(4.5): shows frequency distribution of BMI

BMI	Frequency	Percent
18	2	3.1
19	2	3.1
20	3	4.6
21	4	6.2
22	11	17.1
23	7	10.9
24	6	9.3
25	7	10.9
26	6	9.3
27	5	7.8
28	4	6.2
29	4	6.2
30	1	1.5
31	1	1.5
32	1	1.5

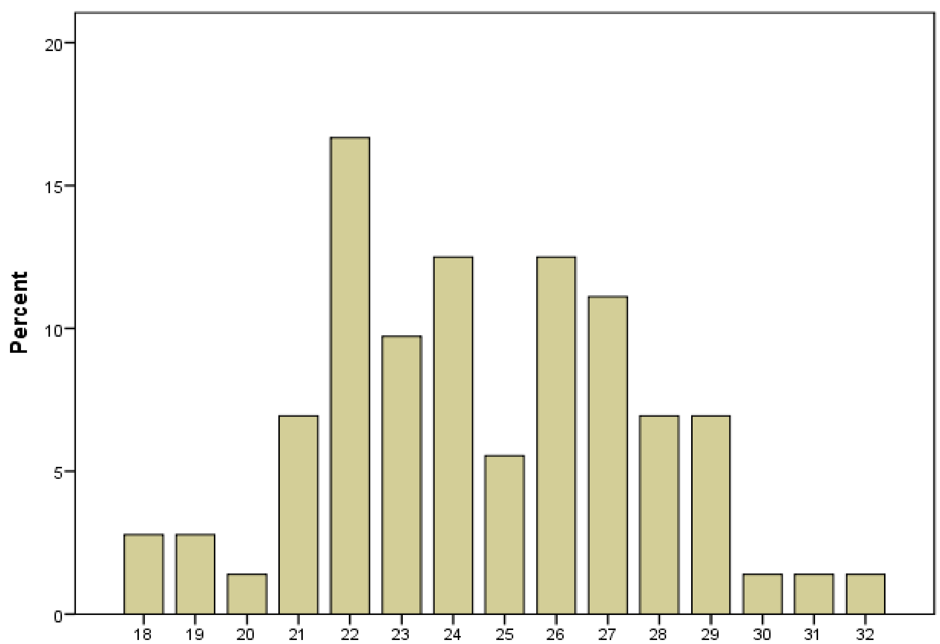

Figure (4.3): show BMI percent.

The following figures demonstrate the scatter plot diagram of the common bile duct diameter and the variables including (Age, BMI chest circumference, abdomen circumference)

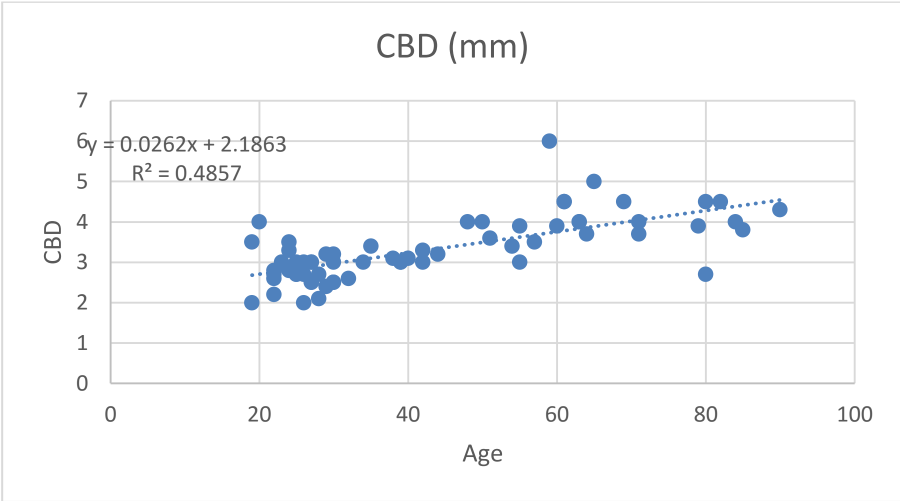

Figure (4.4): A scatter plot diagram show age correlation with CBD diameter.the diameter increase by 0.02 from 2.1 for each 20 years of age.

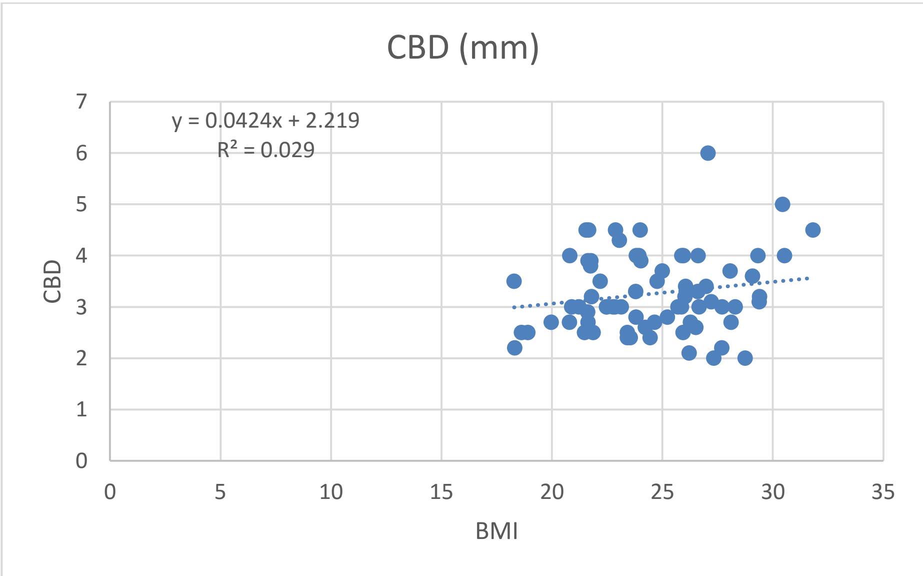

Figure (4.5): A scatter plot diagram show BMI correlation with CBD .revealed that there is no correlation.

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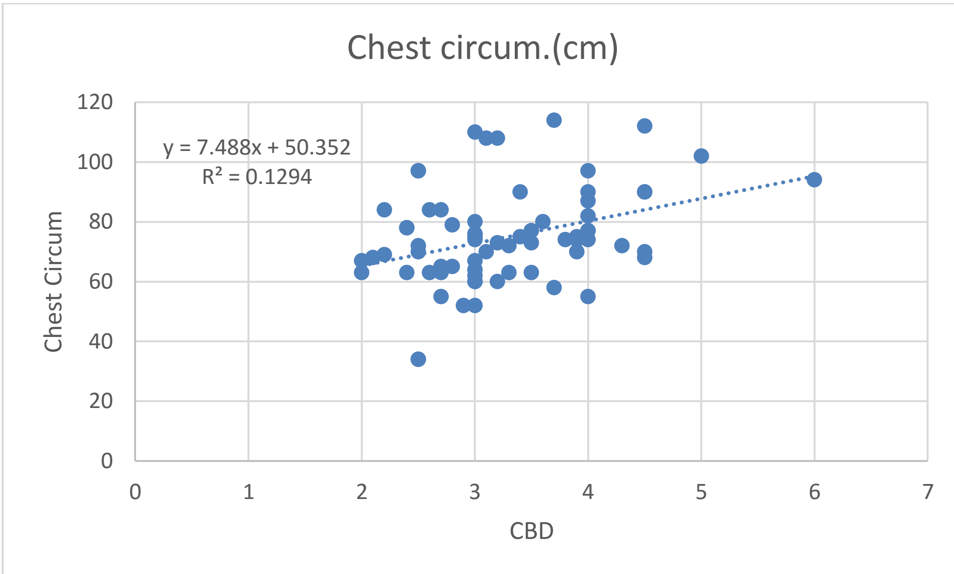

Figure (4.6): A scatter plot diagram show chest circumference correlation with CBD diameter, Revealed that there is no correlation**.**

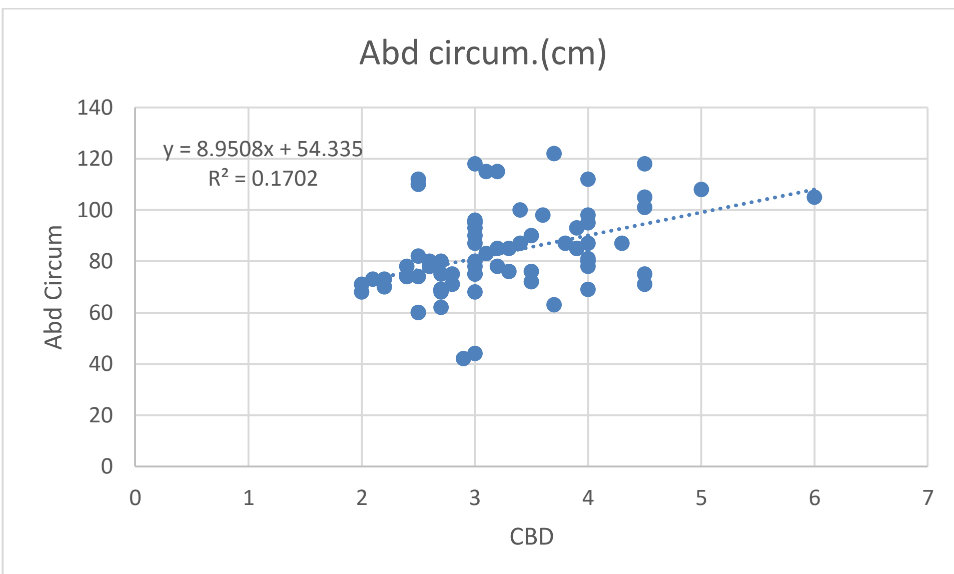

Figure (4.7): A scatter plot diagram show abdomen circumference correlation with CBD diameter revealed there is no correlation.

Chapter Five

Discussion, conclusion and recommendations

5.1 Discussion:

This study was conducted among 64 normal subjects belonging to the state of Khartoum. An equal number of males and females in the age group 19-90 years of age. The mean age was 42.97years (SD 20.745years) as mentioned in Table 4.1. A majority of the participants belonged to the age group 19-39years (frequency 35). As recorded in Table 4.2, were included in the study. The subjects underwent ultrasonography measurements of common bile duct diameters by experienced radiologist at the Hospital of Dar Elelaj in Khartoum. In addition, anthropometric data on weight, height, chest circumference, abdomen circumference, were obtained for each of the study subjects.

The mean diameter observed in our study was 3.31mm with a standard deviation (SD) of 0.789 mm. and the average diameter ranged from 2mm - 6mm with 45% measured (3mm) as seen in Figure 4.2.This was not similar to that reported by Nidhi Lal in his study on 200 normal subjects which reported that the mean equal to 4.1 mm with SD equal to 1.01mm, Average diameter ranged from 2.0 mm to 7.9 mm,

From Table 4.1 The mean weight (65.14kg) with (SD=10.555 kg) the mean of height (161.35cm) and the (SD=9.767cm),BMI was calculated from the height and weight measuring the mean of the BMI is (24.95) and the (SD=2.918), the mean of the chest circumference measured at the middle of the chest (76.46cm) with (SD=14.680cm),the mean of the abdominal circumference (85.97cm) and the (SD=15.251cm).

In accordance with previous results correlation was done to find out the relation between the different variables, the result revealed out that there is significant correlation at the 0.01 level between the age and the CBD diameter as recorded in Table 4.3 and Figure 4.6 A scatter plot diagram show age correlation with CBD diameter. The diameter increase by 0.02 from 2.1 for each 20 years of age. That agrees with the study done by Nidhi Lal which observed a statistically significant relation of common bile duct with age, along with a linear trend and agree with the study done by Daradkeh S which revealed that the factor found to be significantly affecting the diameter of the common bile duct was age, and agrees with the study done by Perret R which found that there is significant change in size with age .

In order to assess the association between common bile duct diameter and anthropometric measurements, both of which were continuous variables, correlation was used Common bile duct diameter was not observed to have statistically significant correlation with any of the anthropometric measurements as recorded in Figure 4.6 and Figure 4.7,same result achieved by Nidhi Lal whose found that the common bile duct diameter did not show any statistically significant correlation with any of the anthropometric measurements.

Figure 4.5 A scatter plot diagram show BMI correlation with CBD .revealed that there is no correlation ,that does not agree with previous study done by Daradkeh S which showed that the factors found to be significantly affecting the diameter of the common bile duct was body mass index.

The common bile duct diameter has positive relationship with age (increase with increasing in age), and has no significant relation with body anthropometry, and no significant correlation with the body mass index.

5.2 Conclusion

- The study found that the average diameter of the normal common bile duct is less than 6mm, study also achieved that there is significant correlation of common bile duct diameter with age as it increase by 0.02 from 2.1 for each 20 years of age and there was no significant association between BMI and anthropometry measurement and the common bile duct diameter.

5.3 Recommendation:

- Ultrasound is a simple, time saving tool for evaluation parts diameter It should be the first investigation to be done to evaluate the normal index for populations.
- Further studies in measurement of common bile duct in different locations with larger sample of population for more accurate results.
- Measurement with different patient body posture for more accuracy and to have limits of normal diameter according to the position of the patient.
- Further studies should be done with more body characteristic.
- Educating and training technologist sonographers and radiologists to perform optimum examination and correct measurements.
- The most profound limitation of the study was the small sample size. So we recommend that study with larger sample size be considered.

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Sudan University of Science and Technology

College of Graduate Studies

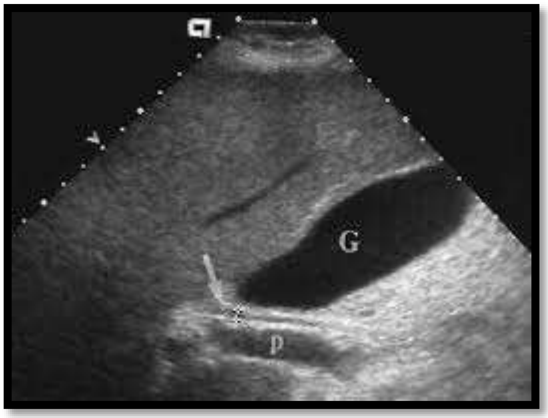
Data collection Sheet

No	Gender	Age	Height	Weight	BMI	CBD (mm)	Chest cir.(cm)	Abd.cir.(cm)

Ultrasound images:

Ultrasound image of 19years female shows the CBD relation with portal vein and longitudinal plane of gall bladder, caliber measuring the CBD diameter.

Ultrasound image of 24 years female shows the caliber measuring the CBD diameter (0.23mm).



Ultrasound image of 79 years male shows the caliber measuring the CBD diameter (4 mm).

Ultrasound image of 90 years male shows the caliber measuring the CBD diameter (4.3mm).

Ultrasound image of 69 years male shows the caliber measuring the CBD diameter (4.3mm).

Ultrasound image of female 35 years shows the normal CBD (3.8 mm).