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MRI, MRCP and Transabdominal SonographicAssessment of the Mean and Upper Limit Diameter of the Non-Obstructed Common Bile Duct in Different Age Groups and Post Cholecystectomy for Early Prediction of Biliary Obstruction

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Abstract

Background: The human biliary system consists of the liver that synthesizes bile and the intra hepatic and extra hepatic biliary passages. The extra hepatic biliary passages include the gall bladder that stores and concentrates the bile and the right and left hepatic ducts that unite to form the common hepatic duct that unites with the cystic duct to form the common bile duct (CBD).

The common bile duct descends in the right free margin of the lesser omentum then behind the first part of the duodenum and the head of pancreas then joins the main duct of pancreas forming the ampulla of Vater (Hepatopancreatic ampulla) that opens into the posteromedial aspect of the second part of duodenum.

Aim of Study: This study was done for assessment of the mean and upper limit diameter of the CBD in the different age groups between 20 and 80 years and after cholecystectomy more than 2 years agofor early prediction of the obstruction or narrowing of the lower part of the CBD.

Subjects and Methods: This study was done on 1000 patients came to Sohag University Hospital with problems not related to the biliary system and examined by magnetic resonance imaging (MRI), magnetic resonance cholangiopancreatography (MRCP) and trans abdominal ultrasonography.

Results: The study demonstrated that, the diameter of CBD increases gradually with age with more widening of CBD after cholecystectomy for more than two years and with no sex related differences in the different age groups.

Conclusion: The diameter of the non-obstructed CBD is proportionally related to the age and increases after cholecystectomy with an upper limit for each age group.

Key Words: *MRI – MRCP – Transabdominal ultrasonography – Common bile duct – Gall bladder – Diameter – Cholecystectomy – Age – Sex.*

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Introduction

COMMON bile duct conducts the bile from the liver and gall bladder to the second part of duodenum. The liver synthesizes the bile that passes in the intrahepatic biliary canaliculi that unite at portahepatis to form the right and left hepatic ducts. The left hepatic duct drains the bile from the left, quadrate and caudate lobes of the liver while the right duct drains the bile from the rest of the right lobe **[1].**

The right and left hepatic ducts unite at an acute angle to form the common hepatic duct that unites with the cystic duct to form the common bile duct. The bile passes through the right and left hepatic ducts then through the common hepatic duct then the cystic duct to reach the gall bladder where the bile is stored and concentrated **[2].**

The CBD descends in the right free margin of the lesser omentum in front of the portal vein and to the right of the hepatic artery, then descends behind the first part of duodenum in front of the portal vein and the inferior vena cava and to the right of the gastroduodenal artery, then descends behind and sometimes embedded in the head of pancreas. CBD then unites with the main pancreatic duct to form the hepatopancreatic duct. The hepatopancreatic duct dilates forming the hepatopancreatic ampulla (Ampulla of Vater) that bulges into the posteromedial aspect of the second part of the duodenum forming the major duodenal papilla and opens on the summit of this papilla **[3].**

The opening of the ampulla of vater into the second part of duodenum is controlled and guarded by the sphincter of Oddi that allows the bile and pancreatic secretions to pass into the duodenum

but prevents the duodenal contents to reach the pancreatic and bile ducts **[4]**.

Embryologically, the liver and the biliary passages are derived from the second part of duodenum as they appear in the fourth week of the intrauterine life as a small bud called hepatic diverticulum that elongates cranially through the ventral mesogastrium then divides into pars hepatica and pars cystica. The pars hepatica elongates then divides into the right and left hepatic ducts that further give the liver cells while the pars cystica gives the gall bladder and cystic duct **[5]**.

The CBD dilates normally with age **[6]** and after cholecystectomy **[7]**. Pathologically, it dilates considerably when obstructed or narrowed atits lower part either acutely as in cases of gall stones moving from the gall bladder **[8]** or chronically as in cases of strictures in the wall **[9]** orcancer head of pancreas compressing the CBD from the outside **[10]**.

Aim of the work: To evaluate the normal diameter of the non-obstructed CBD in the different age groups of adults and after cholecystectomy for radiological prediction of the obstruction or narrowing of the CBD at its lower part.

Subjects and Methods

Site of the study:

The current study was done at the Radiology Department, Faculty of Medicin, Sohag University.

Time of the study: From April 2021 to June 2022.

Subjects:

The study was done on 1000 patients came to the Hospital of Sohag University complaining of problems not related to the biliary system. The patients with history of CBD exploration, CBD pathology, liver disease or endoscopic sphincterotomy were excluded from the study. These 1000 patients were divided into four groups that in turn subdivided into subgroups with 50 patients in each subgroup.

Group I (Males with healthy gall bladder): subdivided according to the age into six subgroups with 50 subjects examined in each subgroup:

1- Subgroup a (20-30 years old).
2- Subgroup b (30-40 years old).
3- Subgroup c (40-50 years old).
4- Subgroup d (50-60 years old).
5- Subgroup e (60-70 years old).
6- Subgroup f (70-80 six years old).

Group II (Females with healthy gall bladder): subdivided according to the age into six subgroups with 50 patients examined in each subgroup:

1- Subgroup a (20-30 years old).
2- Subgroup b (30-40 years old).
3- Subgroup c (40-50 years old).
4- Subgroup d (50-60 years old).
5- Subgroup e (60-70 years old).
6- Subgroup f (70-80 six years old).

Group III (Males with removed gall bladder by cholecystectomy more than 2 years ago): Subdivided according to age into foursubgroups with 50patients examined in each subgroup:

1- Subgroup a (40-50 years old).
2- Subgroup b (50-60 years old).
3- Subgroup c (60-70 years old).
4- Subgroup d (70-80years old).

Group IV (Females with removed gall bladder by cholecystectomy more than 2 years ago): Subdivided according to age into five subgroups with 50patients examined in each subgroup:

1- Subgroup a (40-50 years old).
2- Subgroup b (50-60 years old).
3- Subgroup c (60-70 years old).
4- Subgroup d (70-80 years old).

Methods:

The patients were examined fasting for at least 6 hours by the magnetic resonance imaging (MRI), magnetic resonance cholangio-pancreatography (MRCP) and transabdominal ultrasonography to show the gall bladder and to measure the diameter of the CBD at its middle.

Statistical analysis:

Collection and analysis of the data was done using the analysis of variance (ANOVA) to compare the data obtained from all groups to detect the relation between the diameter of the CBD with the age, gender and previous cholecystectomy as shown in Table (1).

Table (1): Demographic parameters of the studied population, n=1000.

	With healthy GB N=600		With removed GB N=400	
	Count	Column N %	Count	Column N %
Gender:				
Males	300	50.0%	200	50.0%
Females	300	50.0%	200	50.0%
Age group:				
20: <30	100	16.7%	0	16.7%
30: <40	100	16.7%	0	16.7%
40: <50	100	16.7%	100	16.7%
50: <60	100	16.7%	100	16.7%
60: <70	100	16.7%	100	16.7%
70: 80	100	16.7%	100	16.7%

Results

A- *Examination of the groups I and II having healthy gall bladder detected that:*

1- In the age from 20 to 50 years: The diameter of the CBD remains constant from the age of 20 till the age of 50 years old and without sex related differences with a mean of 4.9±0.3mm and the upper limit is 6.2mm (Fig. 1).

2- After the age of 50 years the diameter of the CBD increases gradually with no significant sex related differences in all age groups.

I- In the age of 50-60 years, the diameter increases to reach 5.3±0.5mm and the upper limit is 6.7mm in both males and females (Fig. 2).

II- In the age of 60-70 years, the diameter of the CBD has a mean of 5.6mm and the upper limit is 7.2mm in both males and females (Fig. 3).

III- In the age of 70-80 years, the diameter of the CBD is 6±0.6mm and the upper limit is 7.9mm in both males and females (Fig. 4).

B- *Examination of the groups III and IV (with removed GB by cholecystectomy more than 2 years ago) detected that, removal of the gall bladder at any age is followed by gradual dilatation of the CBD in both males and females:*

I- In the age of 40-50 years with removed GB, the diameter of the CBD is 5.4±0.6mm and the upper limit is 7.3mm in males and females (Fig. 5).

II- In the age of 50-60 years with removed GB, the diameter of the CBD is 6.3±0.5mm and the upper limit is 8 mm in males and females (Fig. 6).

III- In the age of 60-70 years with removed gall bladder, the diameter of the CBD is 7.3±0.5 mm and the upper limit is 8.6mm in both males and females (Fig. 7).

IV- In the age of 70-80 years with removed gall bladder, the diameter of the CBD is 7.9±0.6mm and the upper limit is 9.8mm in both males and females (Fig. 8).

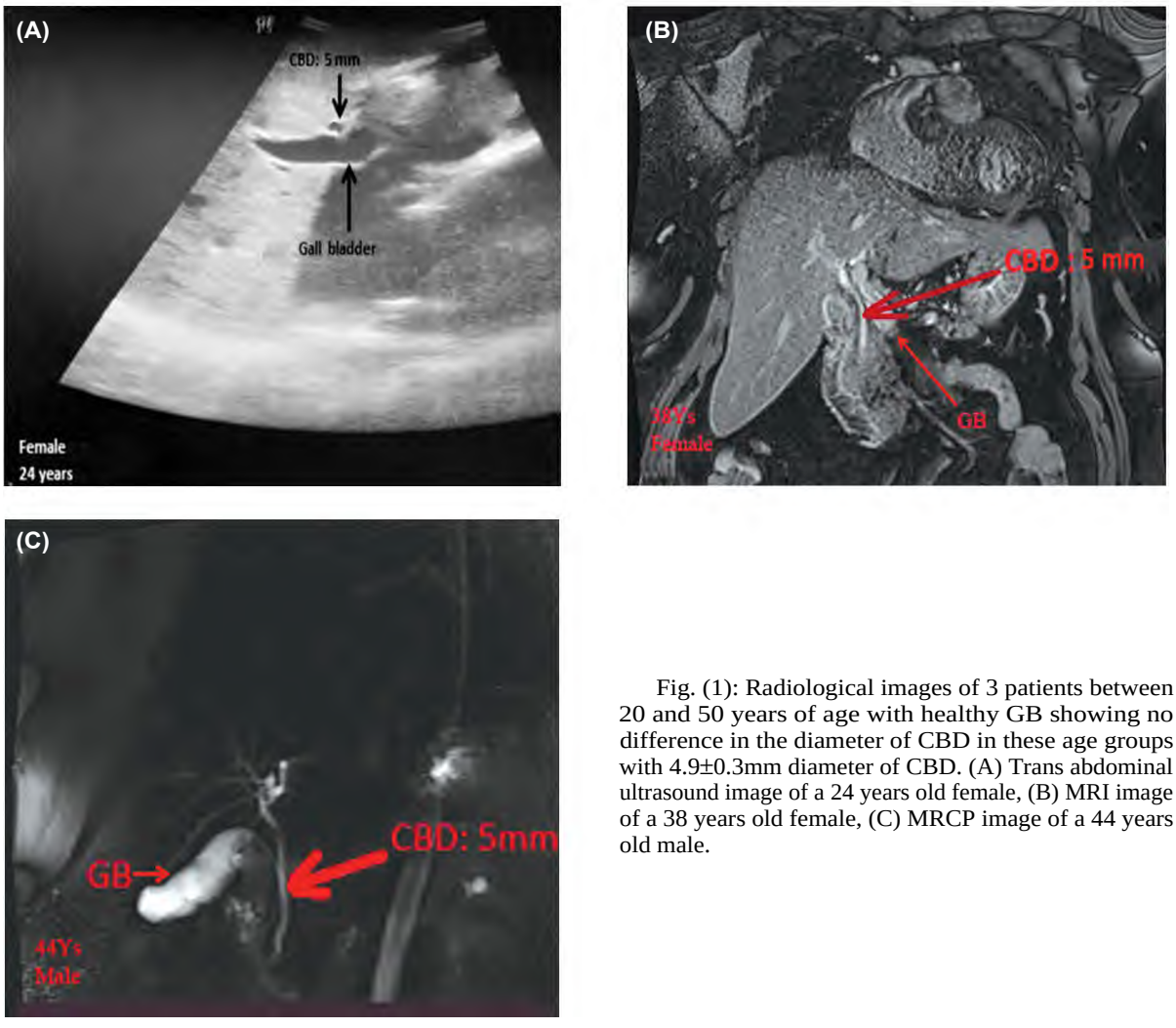

Fig. (1): Radiological images of 3 patients between 20 and 50 years of age with healthy GB showing no difference in the diameter of CBD in these age groups with 4.9±0.3mm diameter of CBD. (A) Trans abdominal ultrasound image of a 24 years old female, (B) MRI image of a 38 years old female, (C) MRCP image of a 44 years old male.

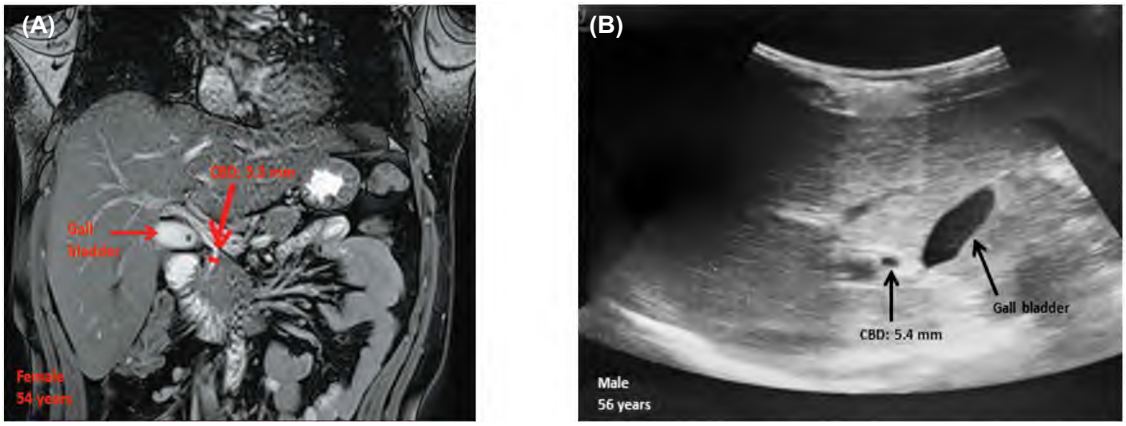

Fig. (2): Radiological images of 2 patients of the age group of 50-60 years old with healthy GB with 5.3±0.5mm diameter of the CBD. (A) MRI image of a 54 years old female, (B) Trans abdominal ultrasound image of a 56 years old male.

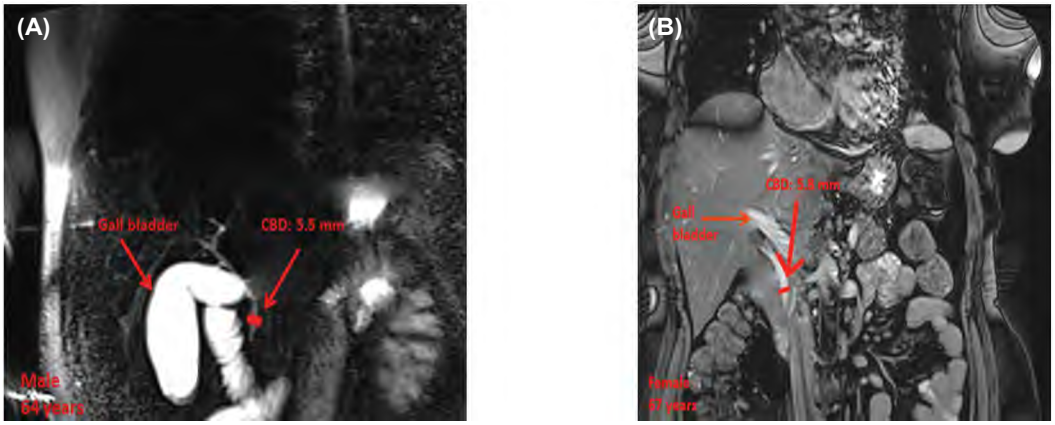

Fig. (3): Radiological images of 2 patients of the age group of 60-70 years old with healthy GB with 5.6±0.5mm diameter of the CBD. (A) MRCP image of a 64 years old male, (B) MRI image of a 67 years old female.

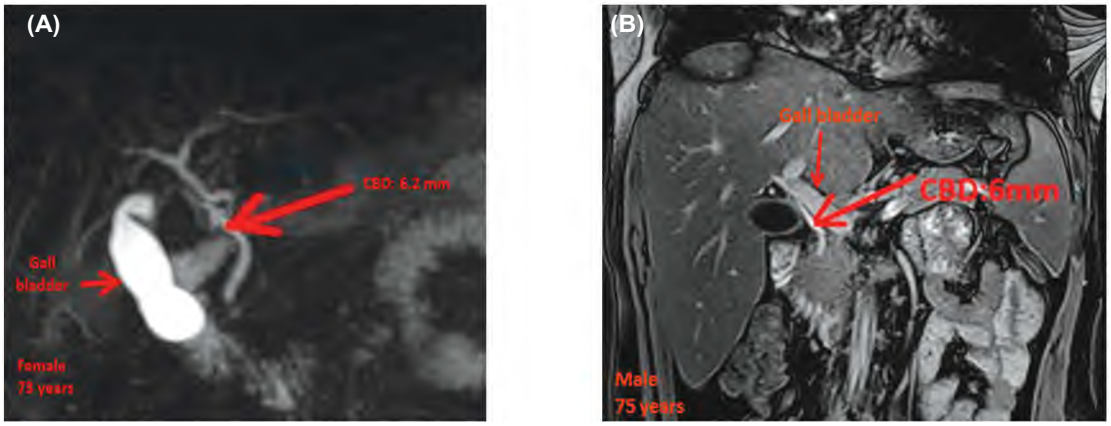

Fig. (4): Radiological images of 2 patients of the age group of 70-80 years old with healthy GB with 6±0.6mm diameter of CBD. (A) MRCP image of a 73 years old female, (B) MRI image of a 75 years old male.

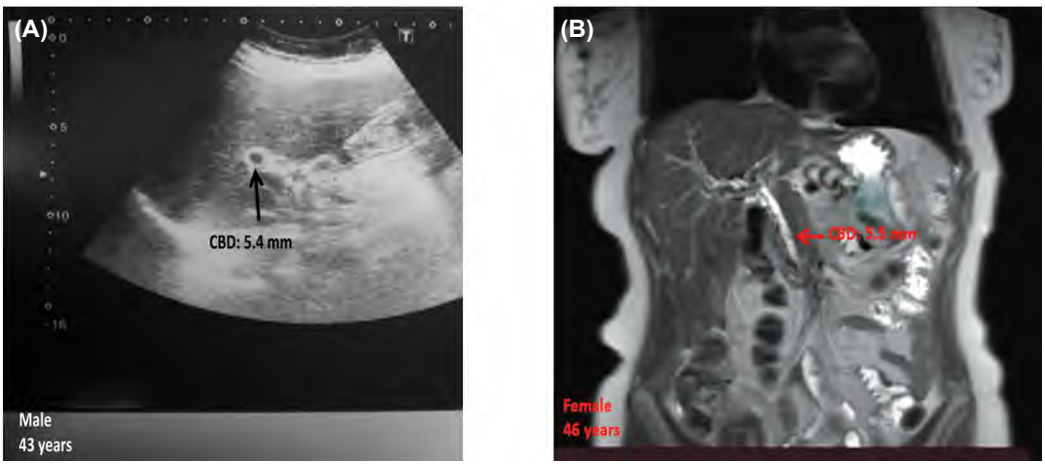

Fig. (5): Radiological images of 2 patients of the age group of 40-50 years old with previously surgically removed GB with 5.4±0.6mm diameter of the CBD. (A) Trans abdominal ultrasound image of a 43 years old male, (B) MRI image of a 46 years old female.

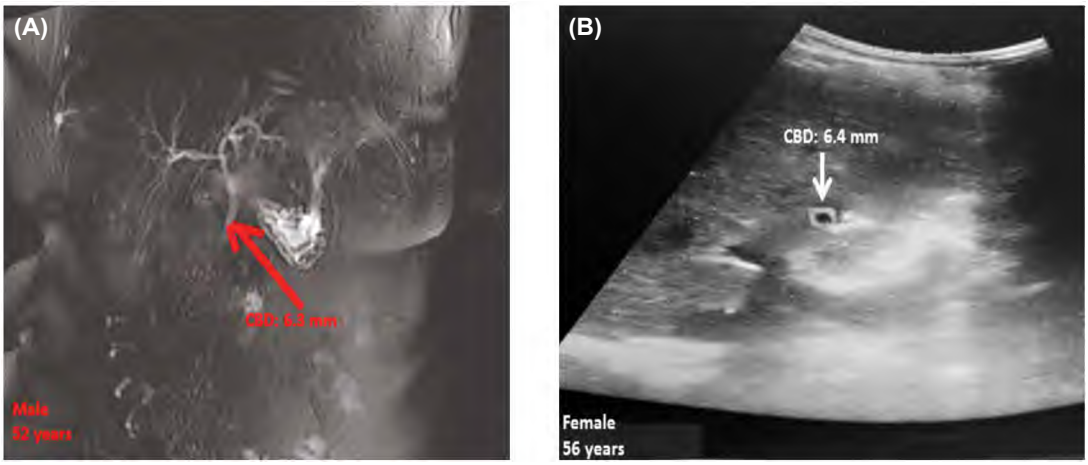

Fig. (6): Radiological images of 2 patients of the age group of 50-60 years old with previously surgically removed GB with 6.3±0.5mm diameter of the CBD. (A) MRCP image of a 52 years old male (B) Trans abdominal ultrasound image of a 56 years old female.

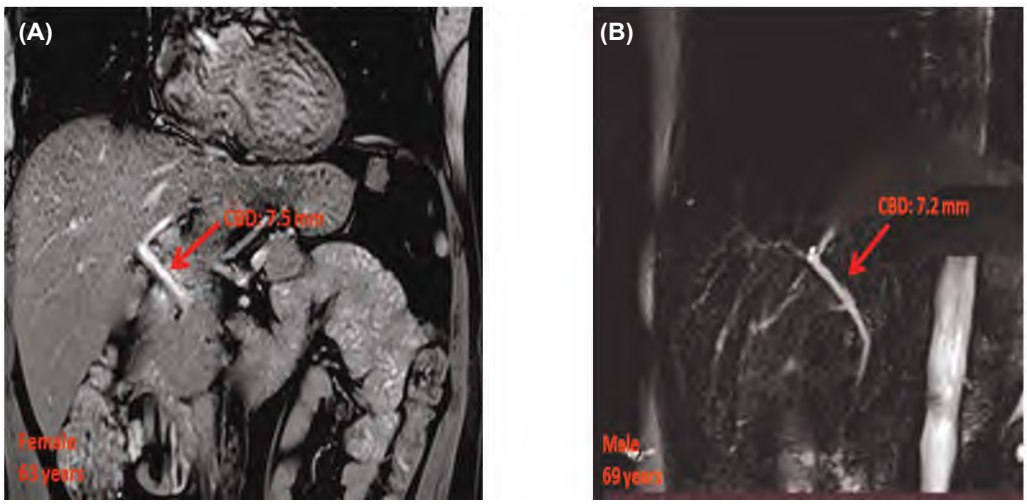

Fig. (7): Radiological images of 2 patients of the age group of 60-70 years old with previously surgically removed GB with 7.3±0.5mm diameter of the CBD. (A) MRI image of a 63 years old female (B) MRCP image of a 69 years old male.

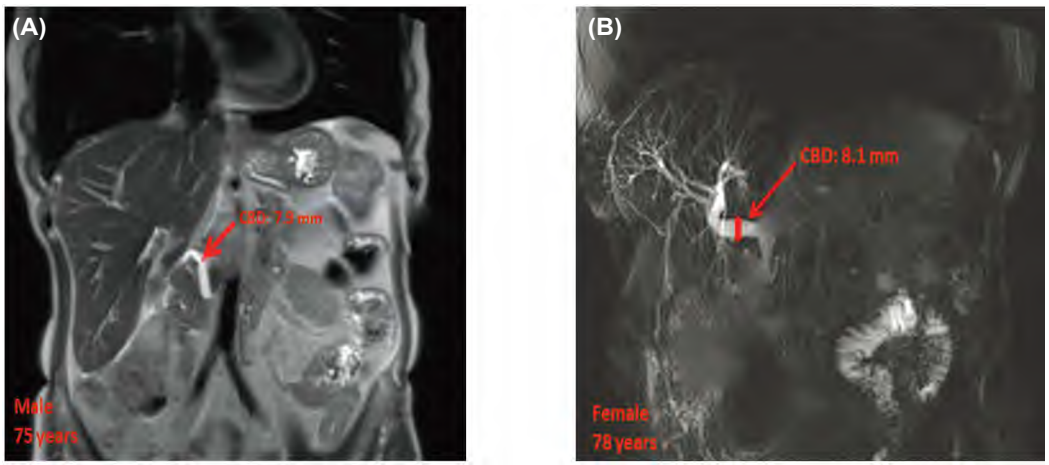

Fig. (8): Radiological images of 2 patients of the age group of 70-80 years old with previously surgically removed GB with 7.9±0.6mm diameter of the CBD. (A) MRI image of a 75 years old male (B) MRCP image of a 78 years old female.

Table (2): Common bile duct diameter in different age groups, n=1000.

	With healthy GB		With removed GB	
	Mean mm ± SD	Upper limit. mm	Mean mm ± SD	Upper limit. mm
20:<30	4.90±.334	6.2		
30: <40	4.91±.326	6.2		
40: <50	4.91±.381	6.2	5.421±.657	7.3
50:<60	5.31±.503	6.7	6.326±.543	8
60:<70	5.61±.572	7.2	7.316±.585	8.6
70:80	6.09±.653	7.9	7.974±.602	9.8
p-value	p_1<0.002		p_2<0.004	

- *p*1 value represent the significant difference in CBD diameter between different age among the group 1 (healthy gall bladder) and was calculated by one way ANOVA test.

- *p*2 value represent the significant difference in CBD diameter between different age among the group 2 (removed gall bladder) and was calculated by one way ANOVA test.

Table (3): Common bile duct diameter in relation to gall bladder status and gender, n=1000.

Gender / Gall bladder status	With healthy gall bladder	With removed gall bladder
	Mean ± SD	Mean ± SD
Gender:		
Male	5.3±0.65	6.770±1.150
Female	5.290±0.641	6.749±1.131
p-value	p_1=0.81	p_2=0.85

- *p*1 value represent the significant difference in CBD diameter between males and females among the group 1 (healthy gall bladder) and was calculated by independent Sample *t*-Test.

- *p*2 value represent the significant difference in CBD diameter between males and females among the group 2 (removed gall bladder) and was calculated by independent Sample *t*-Test.

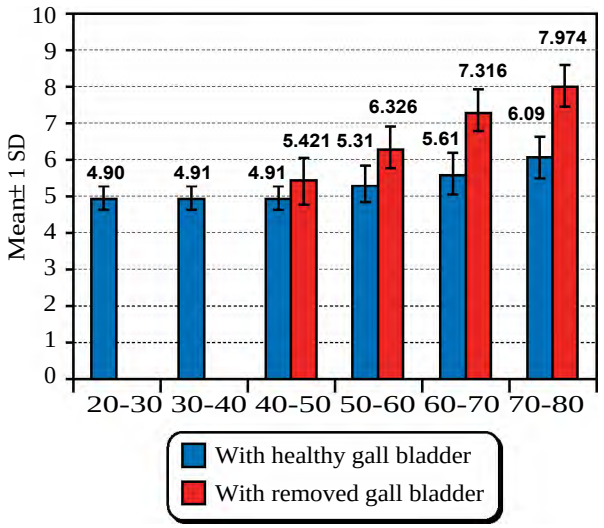

Fig. (9): Common bile duct diameter in different age groups.

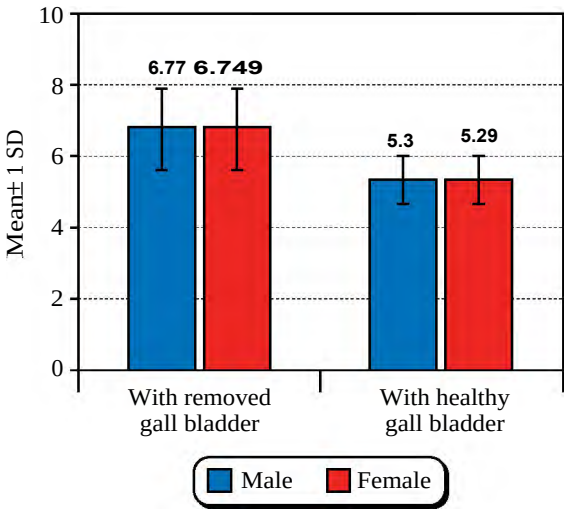

Fig. (10): Common bile duct diameter in different age groups.

Discussion

This study detected that, the diameter of the CBD increases gradually after the age of 50 years old and post-cholecystectomy without significant sex related differences.

The results of this study were in correlation with many previous studies that have also detected that, the diameter of the CBD does not dilate from the age of 20 years till the age of 50 years, then the CBD begins to dilate gradually with age **[11]**.

The dilatation of the CBD after the age of 50 years noticed in the current study and previous studies is attributable to degenerative changes occurring in the wall of the CBD in old ages particularly in the muscle layer with replacement of some muscle cells by fibrous tissue leading to weakness and relaxation of the wall with consecutive dilatation of the CBD **[12]**. Also, previous studies have detected that, the widening of the CBD with age is due to loss of the elastic fibers from the wall or from proximal compensatory dilatation due to fibrosis in the distal part of the CBD. Other studies have reported that, certain drugs such as nitroglycerin and calcium channel blockers that are usually taken in old ages, canlead to loss of the contractility and the tone of the CBD wall **[13]**.

In the current study, the CBD in the patients with previously removed gall bladder is wider than those of the same age but with healthy gall bladder. These findings are in correlation with previous studies have already detected that, cholecystectomy leads to increased CBD diameter. The dilatation of the CBD after cholecystectomy is attributable to the increased amount of the bile passing through the CBD after cholecystectomy because the functions of the gall bladder include concentrating the bile through absorption of water from the bile to decrease its amount **[14,15]**. During storage of bile in the gallbladder, it is concentrated 3-10 folds through removal of certain electrolytes and some water and this is carried out through the active transport of sodium and chloride ions across the epithelium of the gallbladder **[16]**.

In this study, the use of MRI, MRCP and abdominal ultrasonography for measuring the diameter of the CBD was according to their proved accuracy in investigating the extra hepaticbiliary passages **[17,18]**.

In our work the upper limit for the diameter of the patent CBD was 6.2-7.9mm with intact gall bladder and 7.3-9.8mm with removed gall bladder more than 2 years ago. These results are in correlation with results of previous studies proved that, biliary dilation greater than 6-8 millimeters (mm) in a patient with an intact gallbladder, or over 10 mm in a patient post cholecystectomy suggests possible biliary obstruction **[19,20]**.

Conclusion:

In patients undergoing abdominal investigation such as trans abdominal ultrasonography, MRCP and MRI, when these investigation show a dilated CBD above the upper limit of its diameter in relation to the age of the patient and the state of the gall bladder, this dilatation is a predictive sign forobstruction or narrowing of the lower part of the CBD as in cases of choledocolithiasis (Stones in the CBD) and cancer head of pancreas. This means that, further investigations will be needed for diagnosis of the cause of the obstruction or narrowing.

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قياس متوسط والحد الأقصى لقطر القناة المرارية المشتركة الغير مسدودة باستخدام الرنين المغناطيسى والرنين المغناطيسى المرارى البنكرياس والأشعة التليفزيونية على البطن فى الأعمار المختلفة وبعد استئصال المرارة للتشخيص المبكر لانسداد القناة المرارية

مقدمة : تقوم القناة المرارية بنقل العصارة المرارية التى يتم تصنيعها فى الكبد بينما يتم تخزينها وتركيزها فى الحويصلة المرارية. يزداد قطر القناة المرارية مع التقدم فى العمر وبعد استئصال الحويصلة المرارية وفى حالة انسداد القناة المرارية لأى سبب مثل وجود حصوات أو ورم برأس البنكرياس.

الهدف من البحث : تحديد المتوسط والحد الأقصى للقناة المرارية الغير مسدودة مما يفيد فى التوقع والإكتشاف المبكر لانسداد القناة المرارية فى جزئها السفلى.

الأشخاص وطرق الدراسة : أجرى هدا البحث على مريض أتوا إلى مستشفى سوهاج الجامعى صائمين لفترة ليست أقل من ساعات لأسباب لا علاقة لها بالكبد أو الجهاز المرارى وتم فحصهم باستخدام بالرنين المغناطيسى والرنين المغناطيسى المرارى البنكرياسى والأشعة التليفزيونية على البطن. تم فحص المرضى فى أربع مجمو عات.

أ- المجموعة الأولى (ذكور مع وجود حويصلة مرارية سليمة): قسمت حسب العمر إلى ست مجموعات صغيرة تضم كل منها خمسون شخصاً:

١- من ٢٠ إلى ٣٠ عاماً. ٤- من ٥٠ إلى ٦٠ عاماً.
٢- من ٣٠ إلى ٤٠ عاماً. ٥- من ٦٠ إلى ٧٠ عاماً.
٣- من ٤٠ إلى ٥٠ عاماً. ٦- من ٧٠ إلى ٨٠ عاماً.

ب- المجموعة الثانية إناث مع وجود حويصلة مرارية سليمة: قسمت حسب العمر إلى ست مجموعات صغيرة تضم كل منها خمسون شخصاً:

١- من ٢٠ إلى ٣٠ عاماً. ٤- من ٥٠ إلى ٦٠ عاماً.
٢- من ٣٠ إلى ٤٠ عاماً. ٥- من ٦٠ إلى ٧٠ عاماً.
٣- من ٤٠ إلى ٥٠ عاماً. ٦- من ٧٠ إلى ٨٠ عاماً.

ج- المجموعة الثالثة ذكور مع حويصلة مرارية تم استئصالها منذ أكثر من عامين: قسمت حسب العمر إلى أربع مجموعات تضم كل منها خمسون شخصاً:

١- من ٤٠ إلى ٥٠ عاماً. ٣- من ٦٠ إلى ٧٠ عاماً.
٢- من ٥٠ إلى ٦٠ عاماً. ٤- من ٧٠ إلى ٨٠ عاماً.

د- المجموعة الرابعة إناث مع حويصلة مرارية تم استئصالها منذ أكثر من عامين: قسمت حسب العمر إلى أربع مجموعات تضم كل منها خمسون شخصاً:

١- من ٤٠ إلى ٥٠ عاماً. ٣- من ٦٠ إلى ٧٠ عاماً.
٢- من ٥٠ إلى ٦٠ عاماً. ٤- من ٧٠ إلى ٨٠ عاماً.

النتائج : يزداد قطر القناة المرارية تدريجياً بعد عمر خمسين عاماً وبعد استئصال الحويصلة المرارية وبلغ الحد الأقصى لقطر القناة المرارية ٦.٢-٧.٩ مليمتر فى وجود الحويصلة المرارية بينما بلغ ٧.٣-٩.٨ مليمتر فى حالة استئصال الحويصلة المرارية منذ أكثر من عامين.

الإستنتاج : فى حالة اتساع القناة المرارية أكثر من الحد الأقصى الخاص بعمر الشخص وحالة حويصلته المرارية فإن هذا يعنى وجود إنسداد أو ضيق متوقع فى الجزء السفلى من القناة المرارية.