Al – nahrain university

College of medicine

Department of surgery

MAGNETIC RESONANCE CHOLANGIO-PANCREATOGRAPHY FINDINGS IN PATIENTS WITH DILATED BILIARY TREE

A Research submitted to Al-Nahrain University /Collage of Medicine In Partial Fulfilment for the Degree of M.B.CH.B

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Knowledgment

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DEDICATION

To the person who always support and stand with me

My mother

To the person who made everything easy and possible

My father

Special thanks to my best sister(**Shahad Ghanim**)

Abbreviation list:

_CBD	common bile duct
_CT	computed tomography
_ERCP	endoscope retrograde Cholangiopancreatography
_MRI	magnatic resonance image
_MRCP	magnetic resonance Cholangiopancreatography
_OJ	obstructive jaundice
_PTC	percutaneous trans hepatic cholangiography

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ABSTRACT:

BACKGROUND

Magnetic resonance cholangiopancreatography is a relatively non invasive technique of biliary and pancreatic duct imaging. MRCP technique utilizes T2-weighted sequences, in which bile is characterized by high signal intensity, whilst signal intensity of surrounding tissues is reduced. The purpose of this publication was to assess the diagnostic value of magnetic resonance cholangiopancreatography in the diagnostics of biliary dilatation.

Patient AND METHOD :

This cross sectional study was done in Al-Imamain Al-Kadhimiyn medical city and the data were collected between September 2018 & February 2019 from radiology department. The study involved 30 patients with age range between 30-94 years with dilated biliary tree.
Each patient underwent thorough history taking, physical examination, and MRCP imaged on 1.5 T MR Scanner Achieva Philips) .

Results :

Among 30 patient included 20 (67.7%) were female and 10 (33.3%) were mal mean age group 59,9 yr The most common MRCP finding was choledocholithiasis in 46.66% . malignant causes found in 26.66% . Different benign causes in 13.32% AND no identifiable cause by MRCP in 13.32% of cases.

Conclusion:

Magnetic resonance cholangio-pancreatography is a relatively quick, accurate and non-invasive imaging modality for the assessment of patients with dilated biliary tree in ruling out potentially correctable underlying causes and reducing unnecessary invasive interventions.

dilation of biliary tree is more common in female patients, choledocholithiasis is the most common cause , while pancreatic cancer is the most common malignant cause.

Key words: magnetic resonance cholangiopancreatography , dilated biliary tree.

Introduction

Background

It has been more than two decades since magnetic resonance cholangiopancreatography (MRCP) was first described (1). Over this time, the technique has evolved considerably, aided by improvements in spatial resolution and speed of acquisition. It has now an established role in the investigation of many biliary disorders particularly in biliary obstructive pathology , serving as a non-invasive alternative to endoscopic retrograde cholangiopancreatography (ERCP). (1)

Causes of bile duct obstruction

Dilated bile ducts are usually caused by an obstruction of the biliary tree, which can be due to stones, tumors (usually of either the papilla of Vater or the pancreas), benign strictures (due to chronic pancreatitis or primary sclerosing cholangitis), benign stenosis of the papilla (ie, papillary stenosis), or a papillary diverticulum. In developing countries, obstruction is commonly caused by parasites that invade the biliary tree. Less frequent causes of dilated bile ducts include choledochal cysts, which are either congenital or acquired dilatations without obstruction that can be associated with abnormalities of the junction between the pancreatic duct and the bile duct(1)

Figure(1) ; MRCP shows distal CBD stone with intra and extra hepatic dilation

Clinical features:

Those patients with dilated biliary tree will develop biochemical cholestasis. This can present as jaundice, which can be accompanied by pruritus. The patient will also notice that their urine becomes dark and their stool turns pale. If gallstones are the underlying cause, this is typically associated with pain. Conversely, an obstructing cancer causes painless jaundice. The combination of jaundice, fever, and right upper quadrant abdominal pain is called Charcot triad and indicates ascending cholangitis. This is a typical complication of bile duct stones and rarely occurs in the setting of bile duct obstruction due to a cancer unless the bile ducts have been instrumented, for example, by endoscopic retrograde cholangiopancreatography (ERCP).(2)

The role of imaging in biliary obstruction

The goals of imaging are:

(1) to confirm the presence of an extrahepatic obstruction.

(2) to determine the level of the obstruction,

(3) to identify the specific cause of the obstruction

(4) to provide complementary information relating to the underlying diagnosis (e.g., staging information in cases of malignancy).(3)

Imaging modalities in biliary obstruction

Ultrasonography shows the size of the bile ducts, may define the level of the obstruction, may identify the cause and gives other information related to the disease (e.g. hepatic metastases, gallstones, hepatic parenchymal change).(4)

Computed tomography (CT) of the abdomen provides excellent visualization of the liver, gallbladder, pancreas and biliary tree. It can differentiate between intra- and extra-hepatic obstruction.it is modality of choice in staging of cancer of the liver, gallbladder, bile duct and pancrease(5)

ERCP(endoscope retrograde cholangiopancreatography): Widely used , provides diagnostic and therapeutic modality , directly visualize the level of obstruction and identify the cause of obstruction. However It is invasive and associated with complications like cholangitis, biliary leakage, pancreatitis and bleeding.(5)

MRCP

Basic physical principle

MRCP makes use of heavily T2-weighted pulse sequences, thus exploiting the inherent differences in the T2-weighted contrast between

stationary fluid-filled structures in the abdomen (which have a long T2 relaxation time) and adjacent soft tissue (which has a much shorter T2 relaxation time). Static or slow moving fluids within the biliary tree and pancreatic duct appear of high signal intensity on MRCP, whilst surrounding tissue is of reduced signal intensity. The introduction of faster gradients and a parallel acquisition technique has resulted in even greater spatial resolution and faster acquisition times. (1)

Recent advances in MRCP technique

More recently, functional assessment of biliary excretion and pancreatic exocrine function has become possible with the use of hepatobiliary contrast media (6) and secretin (7) respectively.

secretin-stimulated MRCP

Secretin is an endogenous hormone normally produced by the duodenum, which stimulates exocrine secretion of the pancreas. When given as a synthetic agent intravenously (1 ml/10 kg body weight), it improves the visualisation of the pancreatic duct by increasing its calibre. Pancreatic juice flows out of the major duodenal papilla to progressively fill the duodenum Its effect starts almost immediately and peaks between 2 to 5 mins. By 10 min, the calibre of the main pancreatic duct should return to baseline with persistent dilatation of >3 mm considered abnormal. The indications for this technique include the detection and characterisation of pancreatic ductal anomalies and strictures, evaluation of the integrity of the pancreatic duct, characterization of any communication between the pancreatic duct and pseudocysts/pancreatic fistulas, and the assessment of pancreatic function and sphincter of Oddi dysfunction(6).

Functional MR cholangiography

This involves the use of MR lipophilic paramagnetic contrast agents, which when given intravenously, show hepato-biliary excretion. Contrast agents include gadobenate dimeglumine gadolinium ethoxybenzyl diethylene triamine penta-acetic acid and, historically, mangafodopir trisodium .Delayed imaging in the axial and coronal plane, performed between 10-120 min following intravenous administration, normally results in hyper-intense bile on 3D T1-weighted fat-saturated GRE images. The signal-to-noise ratio is higher than conventional T2-weighted MRCP, allowing better delineation of the bile ducts. This technique can be used for similar indications as for T2-weighted MRCP and in most cases has a similar diagnostic accuracy. It is more expensive than conventional T2-weighted MRCP and only the biliary tree is depicted. For these reasons, most centers continue to use conventional T2-weighted MRCP. However, functional MRCP does have a number of advantages, as follows:

1. It better demonstrates communications between cystic lesions and draining bile ducts in the diagnosis of congenital biliary disorders (e.g. Caroli's disease) (8)

2. It helps to distinguish true obstruction in a dilated biliary system (where delayed or no biliary excretion is demonstrated) from pseudo-obstruction (6)

3. It can demonstrate active extravasation of contrast in suspected bile leaks (9)

Normal anatomy on MRCP

Only central intra-hepatic bile ducts are normally seen on MRCP usually measuring up to 3 mm in diameter, whilst extra-hepatic bile ducts should not exceed 7 mm. In patients with a previous cholecystectomy, mild biliary dilatation occurs, with the CBD measuring up to 10 mm in diameter. The intra-hepatic biliary drainage system parallels the portal venous supply. The right hepatic duct has two major branches: the right posterior duct, which has an almost horizontal course (draining posterior segments VI and VII), and the right anterior duct, which has a more vertical course (draining the anterior segments V and VIII). The right posterior duct usually runs posterior to the right anterior duct and fuses with it on its left (medial) side. The left hepatic duct drains segments II-IV and joins the right hepatic duct to form the common hepatic duct. Segment 1 drains via a separate bile duct usually into the origin of the left or right hepatic duct.The pancreatic duct should be no greater than 3 mm, with the main pancreatic duct of Wirsung normally draining into the major duodenal papilla along with the CBD (91% of individuals). An accessory pancreatic duct of Santorini may be present in 45%, which drains into the minor duodenal papilla. The cystic duct usually joins the extra-hepatic duct from the right lateral aspect in 50% of cases, although it may insert into its anterior or posterior aspect in 30% and medial aspect in 20% of individuals.(10) as show in figure {2}(10) .

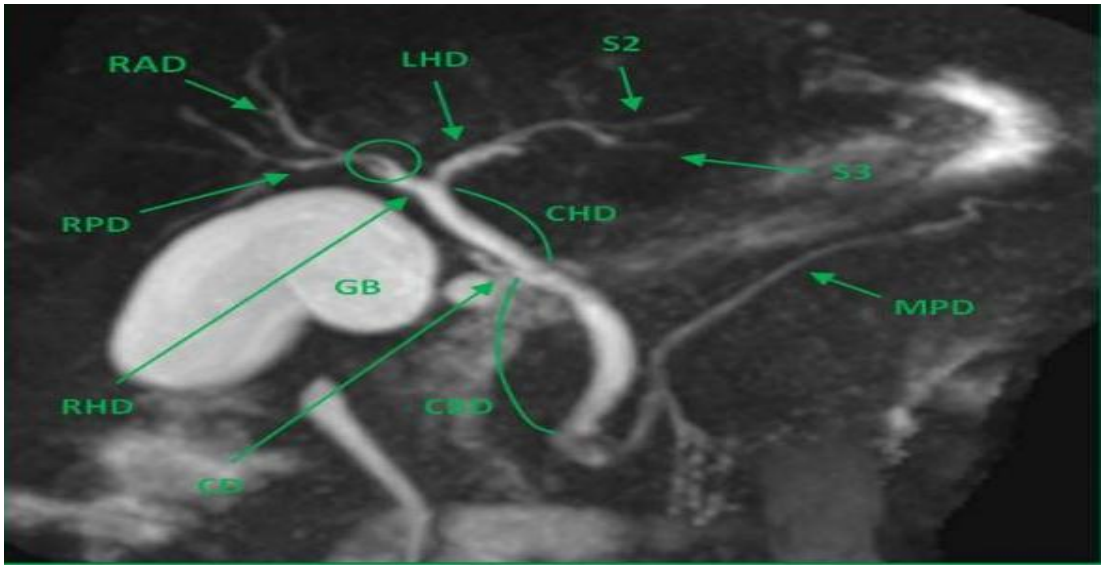


Figure 2:Normal anatomy on MRCP. The confluence of the right and left intrahepatic ducts to form the common hepatic duct is seen (long thin arrow). The cystic duct (*) typically joins the right side of the common hepatic duct to form the common bile duct (CBD)

MRCP protocol

Patients should fast for 3–6 hours prior to examination to reduce residual fluid in the stomach and bowel, increase gallbladder filling, and decrease duodenal peristalsis (11). The use of antiperistaltic agents or negative oral contrast agents has been reported as an adjunct measure to increase image contrast but is considered optional (11). An axial 2D breath-hold HASTE sequence two 3D respiratory-triggered heavily T2-weighted FSE sequences in the coronal oblique plane. The imaging plane is selected from the initial axial T2-weighted images, with one acquisition aligned to the common bile duct (CBD) in the head of the pancreas and the second acquisition aligned to the pancreatic duct at approximately 90 degrees to the first imaging plane. Respiratory triggering is used .The patient is asked to breathe regularly throughout this acquisition, which takes between 3-5 min to acquire. A stack of 40 slices are obtained, which are contiguous and each of 1.5 mm in thickness. As the images are heavily

T2-weighted, the pancreatico-biliary tree is displayed as high signal intensity, whilst adjacent structures are of reduced signal intensity. This sequence is useful in detecting small filling defects or strictures in the biliary or pancreatic ducts. In order to evaluate the duct walls, and any focal parenchymal pathology, 3D fat suppressed T1-weighted GRE sequences before and after intravenous contrast administration can also be performed.(8)

Pitfalls on MRCP

A number of pitfalls may arise which fall into four main categories: (1) artefacts related to technique and reconstruction; (2) normal variants mimicking pathology; (3) intra-ductal factors; (4) extra-ductal factors.

Technique and reconstruction artefacts

Artifacts related to MR imaging technique or post processing, including incomplete volume acquisition or incorrect reconstruction of a sub volume of ductal data, may create pseudo strictures Avoidance of these pitfalls requires meticulous attention to both the source images and the post processed images.(12)

Normal variants

A long cystic duct running parallel to the CBD may simulate a dilated common duct, whilst a contracted choledochal sphincter may mimic an impacted stone or stricture in the distal CBD. En face visualisation of the cystic duct insertion into the bile duct may also simulate

a filling defect. Performing MRCP in multiple imaging planes or carrying out repeat MRCP imaging will help resolve these problems (12).

Intra-ductal factors

Filling defects in the bile may arise, not only from bile duct calculi but also from the presence of gas, debris, hemorrhage and tumor. Aerobilia is seen as a non-dependent filling defect on the axial images figure {3} whilst a signal void in the central part of the bile duct is due to flow phenomenon and may occur in dilated ducts and at the point of insertion of a large cystic duct. The presence of iodinated contrast material will also reduce the signal intensity of bile (12).

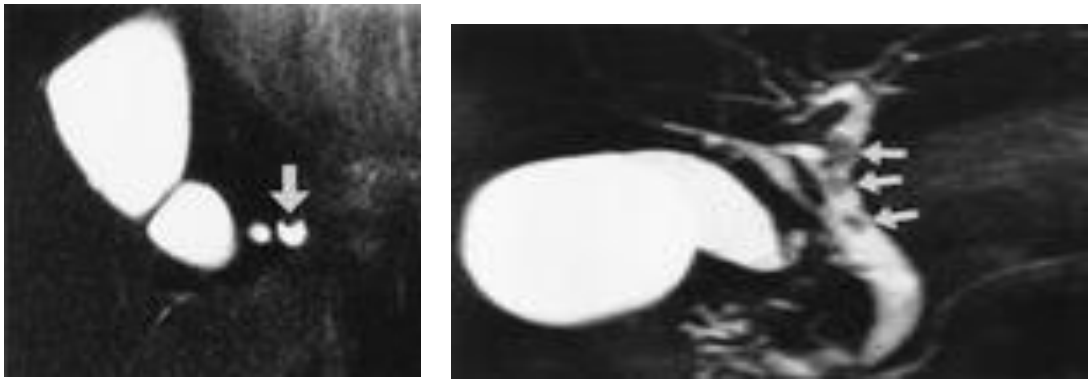


Figure (3) :Pneumobilia. (a) MRCP image shows defects within the common bile duct (arrows), findings that raise suspicion for common bile duct stones. (b) Axial MRCP image demonstrates a defect floating ventrally to the bile (arrow), a finding that indicates the defect to be pneumobilia

Extra-ductal factors

Pulsatile vascular compression from adjacent vessels may mimic a stricture. The commonest site of extrinsic vascular compression is the common hepatic duct, followed by the left hepatic duct, both due to the right hepatic artery crossing its posterior aspect The mid portion of the CBD may also be narrowed due to the gastro-duodenal artery. Pseudo-obstruction is typically seen as a band like compression with minimal proximal dilatation. Susceptibility artifacts from metallic clips and gas may give rise to difficulties in interpretation, although titanium clips used nowadays for cholecystectomy are not magnetic. Overlapping of the biliary tree with other stationary fluids (i.e. from adjacent bowel, cystic collections or ascites) may also cause interpretation Problem (12)

Aim of study:

To assess the role of MRCP in evaluating patients with dilated biliary tree

Patient and Method

This cross sectional analytic study was done in Al-Imamain Al-Kadhimiyn medical city and the data were collected between September 2018 & February 2019 from the MR unit in the radiology department.
The study included patients with dilated biliary tree detected by MRI /MRCP performed for various indication.
Excluded form the study were patient with prior history of biliary ducts intervention (stenting etc…) and patients with dilated biliary ducts during routine scanning for whom MRCP was no done.
The total patients included in the study were 30

MR examination

Each patient underwent MRI imaging on 1.5 T MR Scanner (Achieva , Philips)
The following sequences were employed: coronal T2, axial T2 fat suppression, axial T1, and MRCP. Additional sequences were added as required according to the situation including contrast enhanced images.
The MR exams of eligible patients were loaded on a CD and analysed on a personal computer using the DICOM viewer software (RadiAnt)

Image analysis

The image interpretation was done by the researcher (student) with the revision done by a specialist radiologist (the supervisor)
Image analysis included documenting the level of the obstruction of the biliary tree , the presence and degree of dilatation of the CBD , the cause of the obstruction if possible. Additional data analysed were the size of the GB (contracted or distended) , the presence of pancreatic duct dilatation.

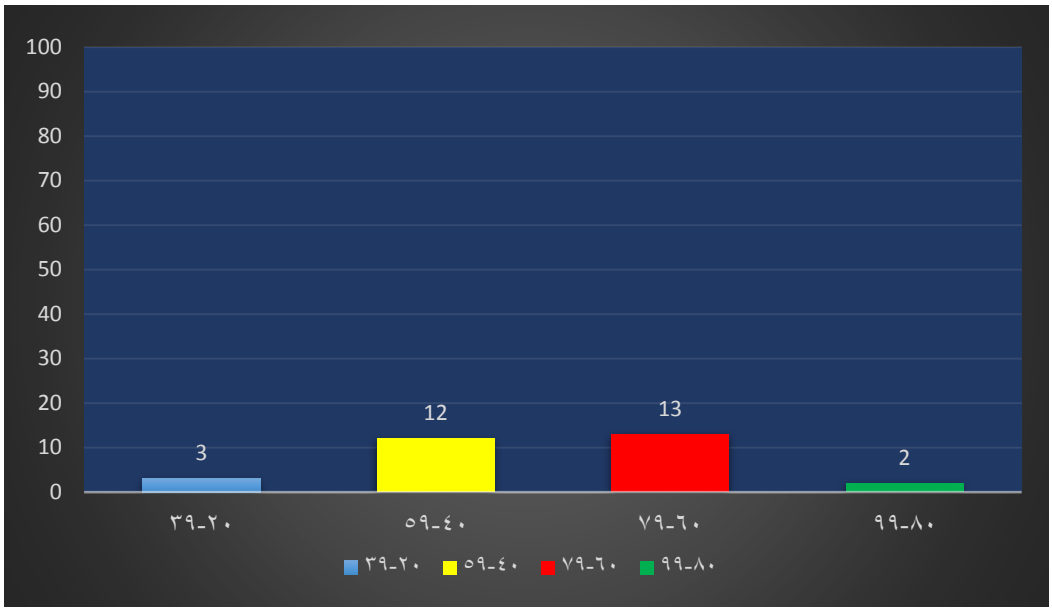
Statistical analysis

the data were analyzed manually and represented in the form of frequency and percentage for variables in tables and graphics design using Microsoft excel software.

Results

1- Age distribution:

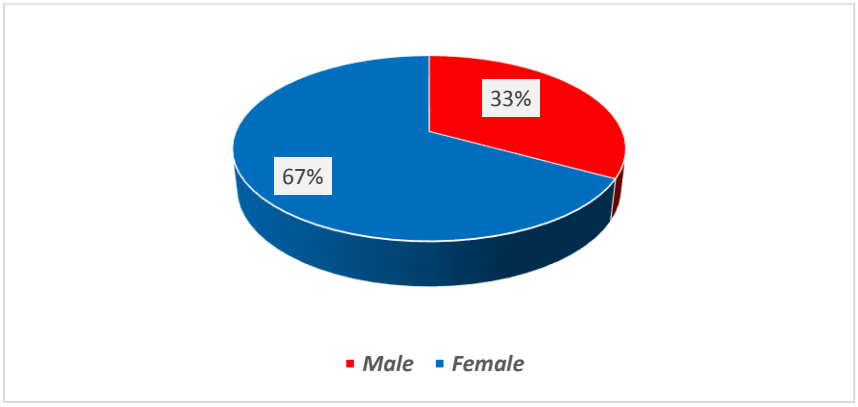
In this study 30 patents were included , there age range from (30-94)year, average age was (59,96 yr). large percentage of them was 43,33was between(60-79) year.



Figure(4):age distribution in patients with dilated biliary tree.

2- Gender:

30 patients were included in this study , 20 female patients (67%)and 10 patiens male (33%)



Figure(5):sex distribution in patients with dilated biliary tree .

3- Diameter of CBD

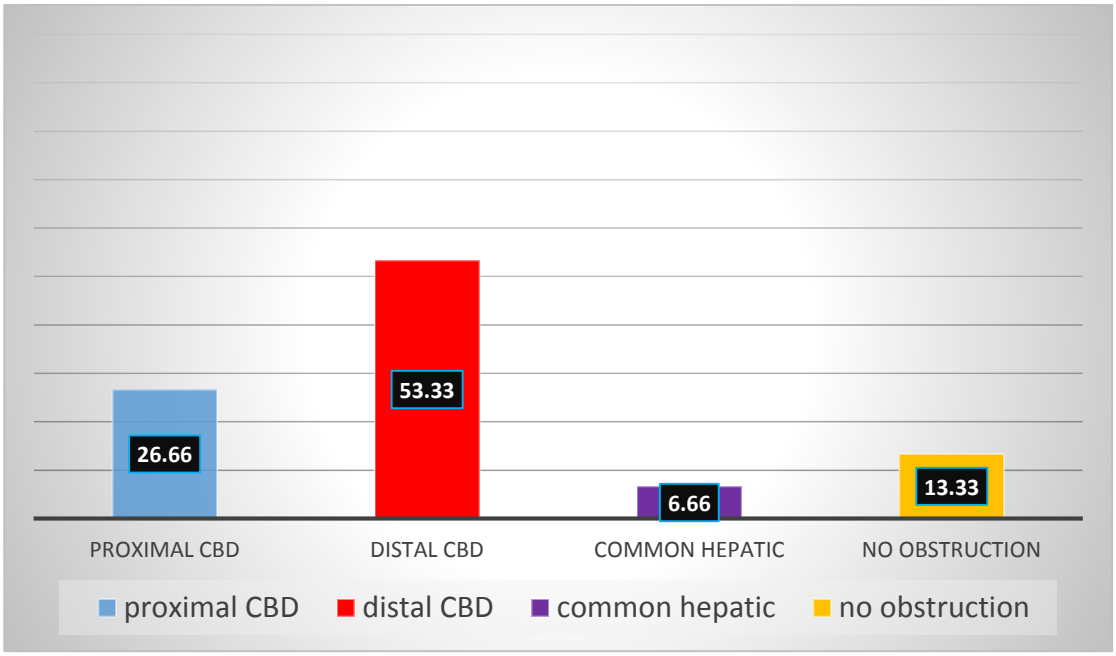
CBD diameter in patients with dilated biliary tree, largest percentage (40%) there diameter was (8-11.9 mm)

Table(1): diameter of CBD in patients with dilated biliary tree.

Diameter of CBD(mm)	Frequency	Percentage
8-11.9	12	40%
12-15.9	11	36.66%
16-19.9	4	13.33%
>20	3	10%

4- Level of obstruction

Level of obstruction in biliary tree , 53,33 % percentage was at the distal CBD ,while 13,33 % with no definitive obstructive lesion.



Figure(6):level of obstruction in patients with dilated biliary tree.

5- **Cause of CBD dilation:**

The cause of dilation was stone in 14 (46.66%) of patients , malignant cause in 8 (26,66%) of patients , no identifiable cause in 4(13,33%) of patients .

Table(2): this table shows the distribution of the causes of dilated CBD.

Causes	Frequency	Percentage
CBD stone	14	46.66%
choledochal cyst	1	3.33%
Ruptured hydatid cyst	1	3.33%
Inflammatory stricture	2	6.66%
pancreatic tumor	4	13.33%
Malignant comprssion by GB Tumor	2	6.66%
cholangiocarcinoma	2	6.66%
unknown	4	13.33%

6-Relationship between causes & GB finding:

In 7 (23.32 %) patients gallbladder is with cholycystectomy , while it distended in15 (50%) of patinets and collaosed in 5(16,66%) of patients

Table(3): shows the relation between gallbladder finding in different pathology.

cause	cholecystectomy	distention	collapse	normal	Total
BD stone	10%	9.99%	16.66%	10%	46.66%
malignancy	6.66%	20%	0	0	20.66%
Other causes	6.66%	16.66%	3.33%	0	20.66%
total	23.32%	49.99%	19.99	10%	100%

7- Relationship between CBD diameter & underlying causes:

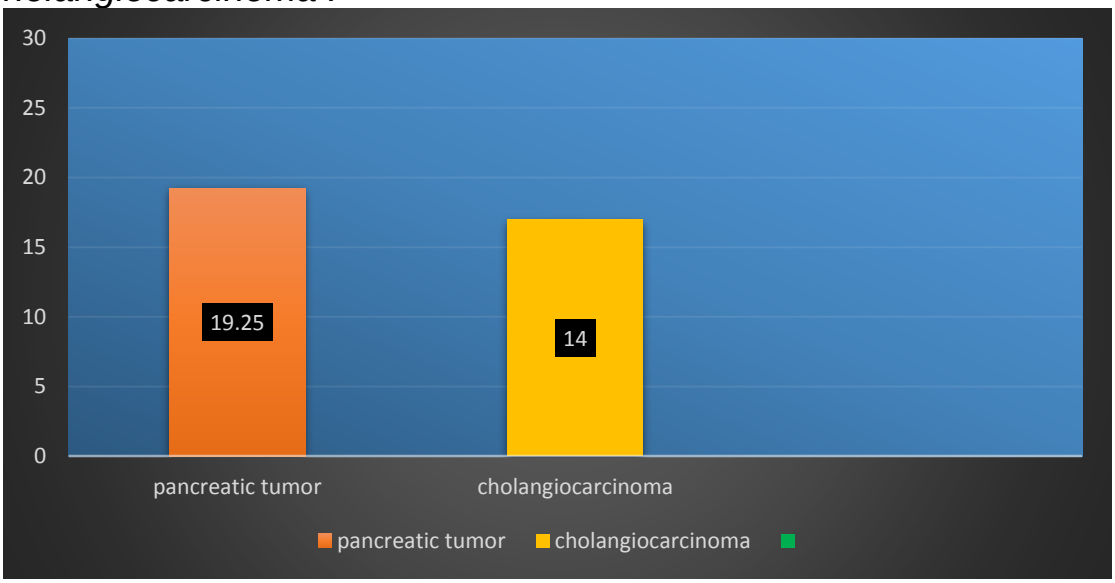
the average of CBD diameter was 13mm in 14 patients with CBD stone and 16.62 mm in 8 patients with underlying malignant pathology .

Table(4): table demonstrate the average of CBD diameter in different causes.

Cause	average of CBD diameter
Malignancy	16.62 mm
CBD stone	13 mm
Benign causes other than stone	13 mm

8 – diameter of CBD in patients with malignancy

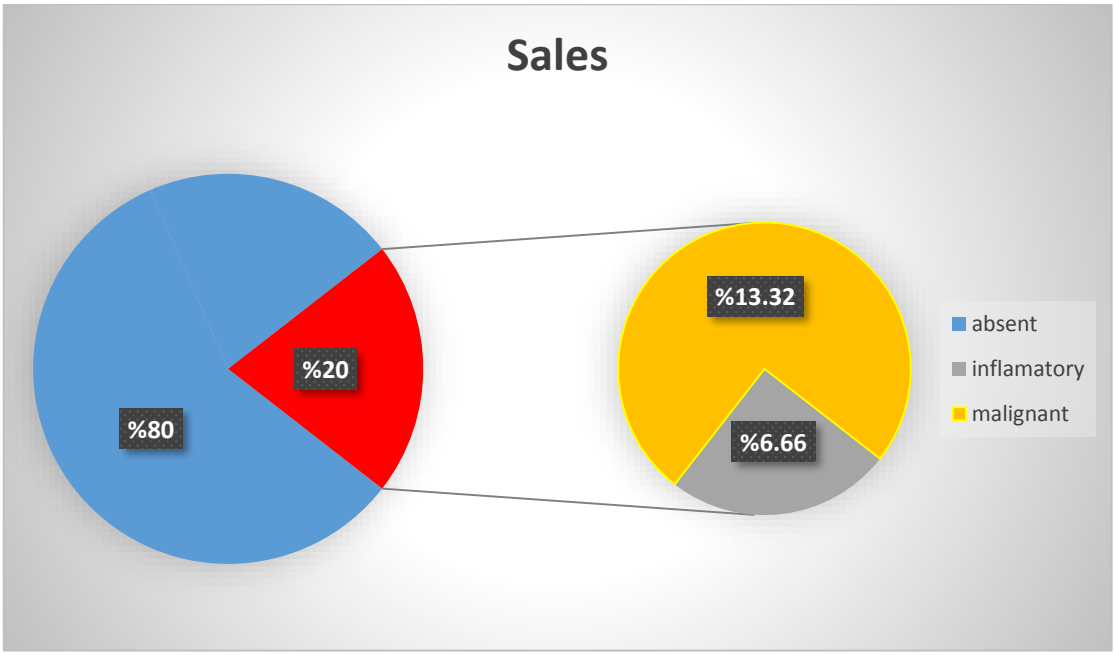
the diameter of CBD was (19.25 mm in the patients with pancreatic head tumors while the diameter was 14 mm in those patients with cholangiocarcinoma .



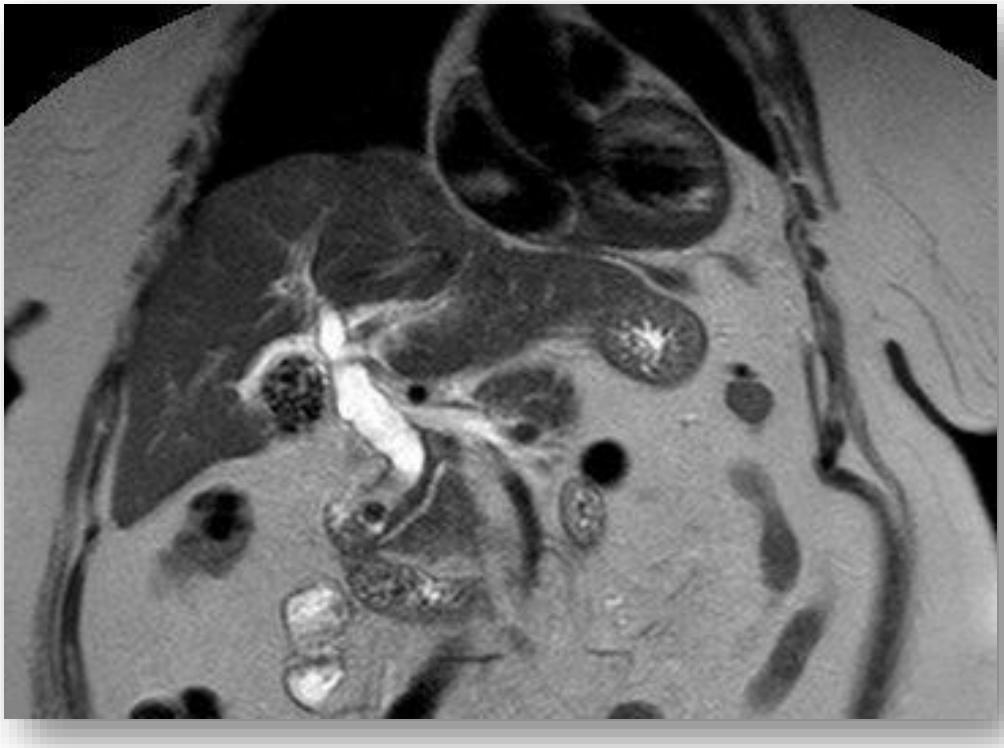
Figure(7): this figure shows the average of CBD dimater in different malignant causes .

9- CBD stricture.

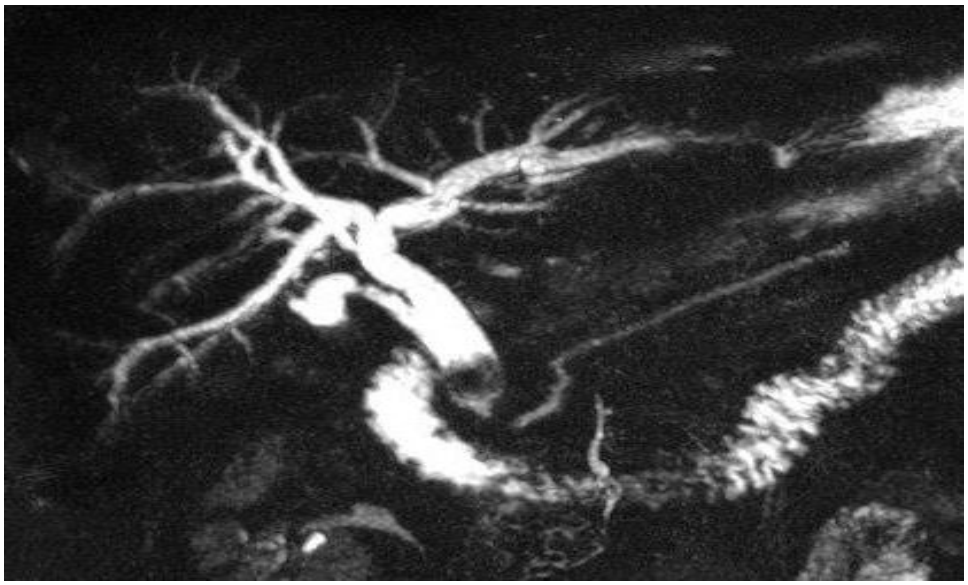
CBD stricture is present in 33.3% of patients ,(26.64%) was in those with malignant causes and (6.66%) in patients with inflammatory causes.



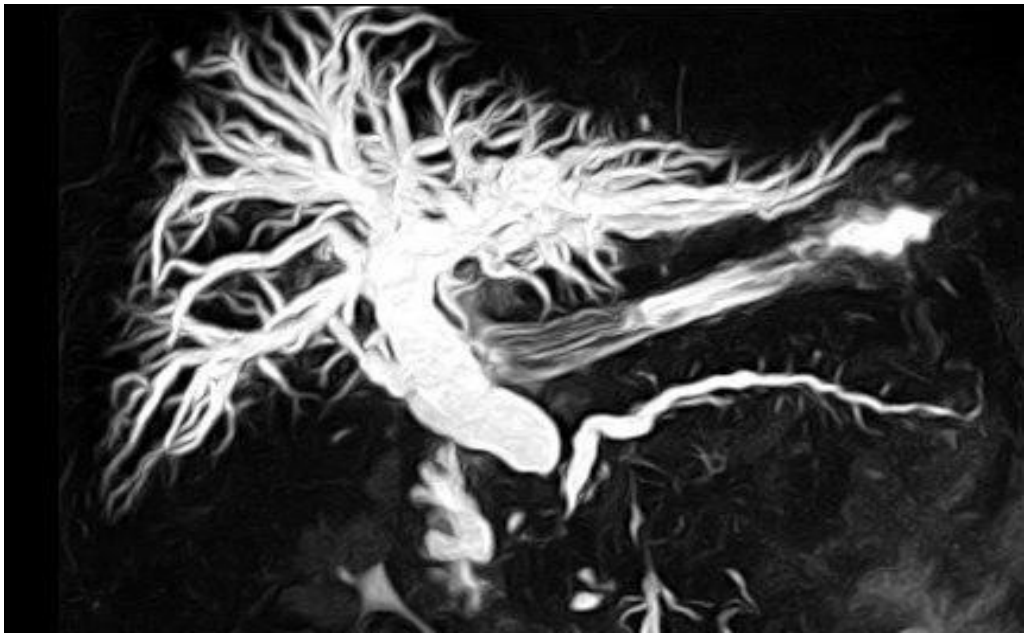
Figure(8): this figure demonstrate the percentage of CBD stricture.



Figure(9) : coronal T2 MRCP image shows distal common bile duct stone with dilated biliary tree , and gallbladder is collapsed and filled with multiple small size stones .



Figure(10) : coronal MRCP projectional image showing dilated intrahepatic duct and CBD with distal filling defect suggestive of choledocolithiasis .



Figure(11) : MRCP image ,tumor of the head of pancreas ,dilated intra - and extrahepatic biliary duct with distal stricture and irregularly enlarged pancreatic duct with dilated secondary ducts .

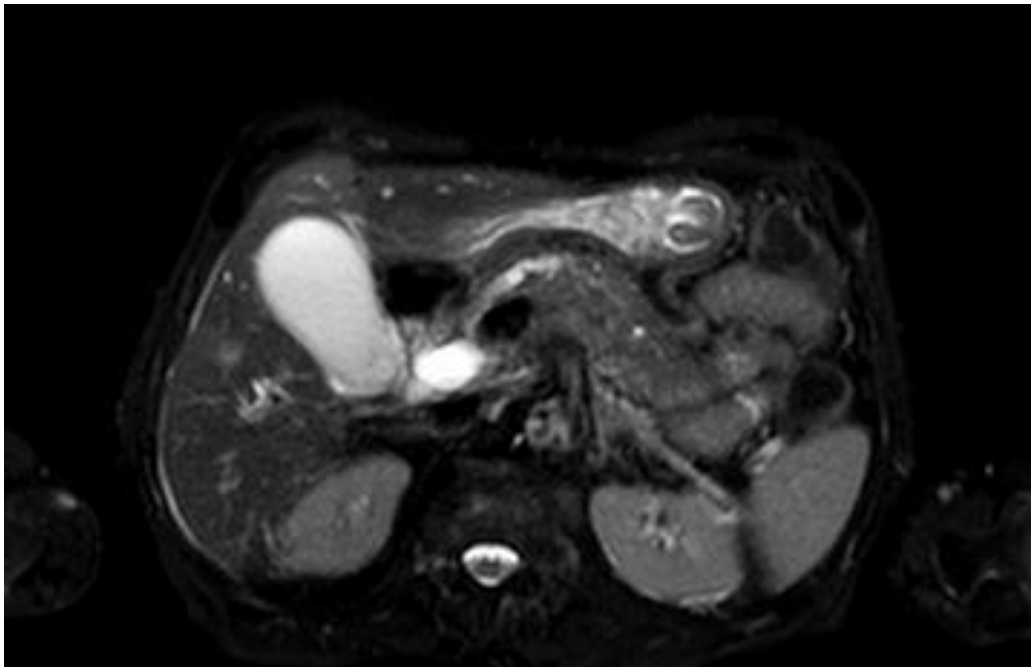
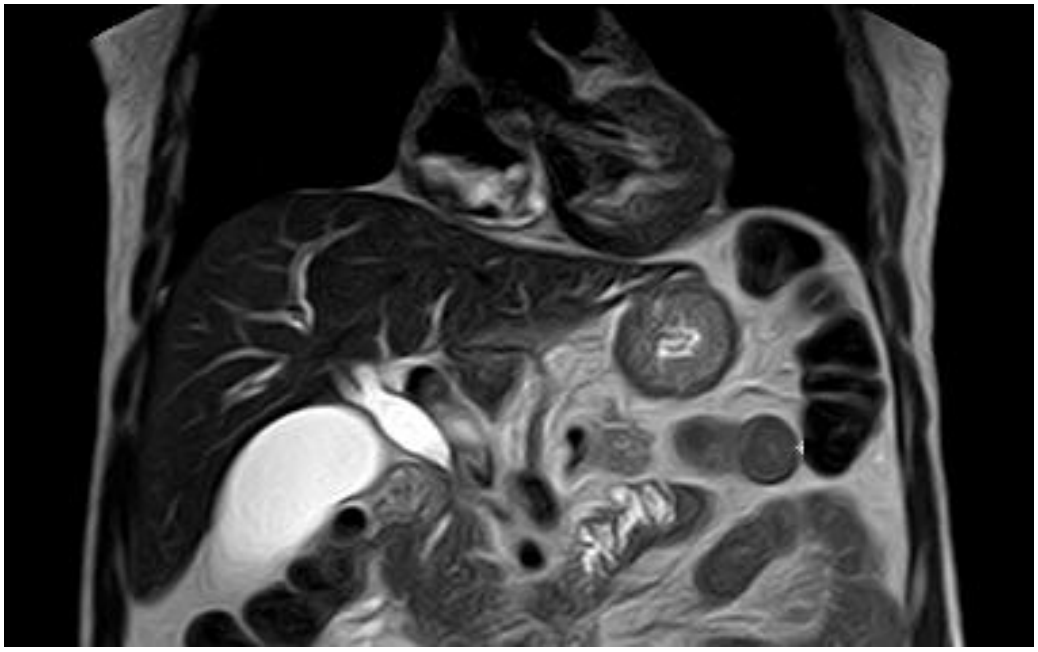
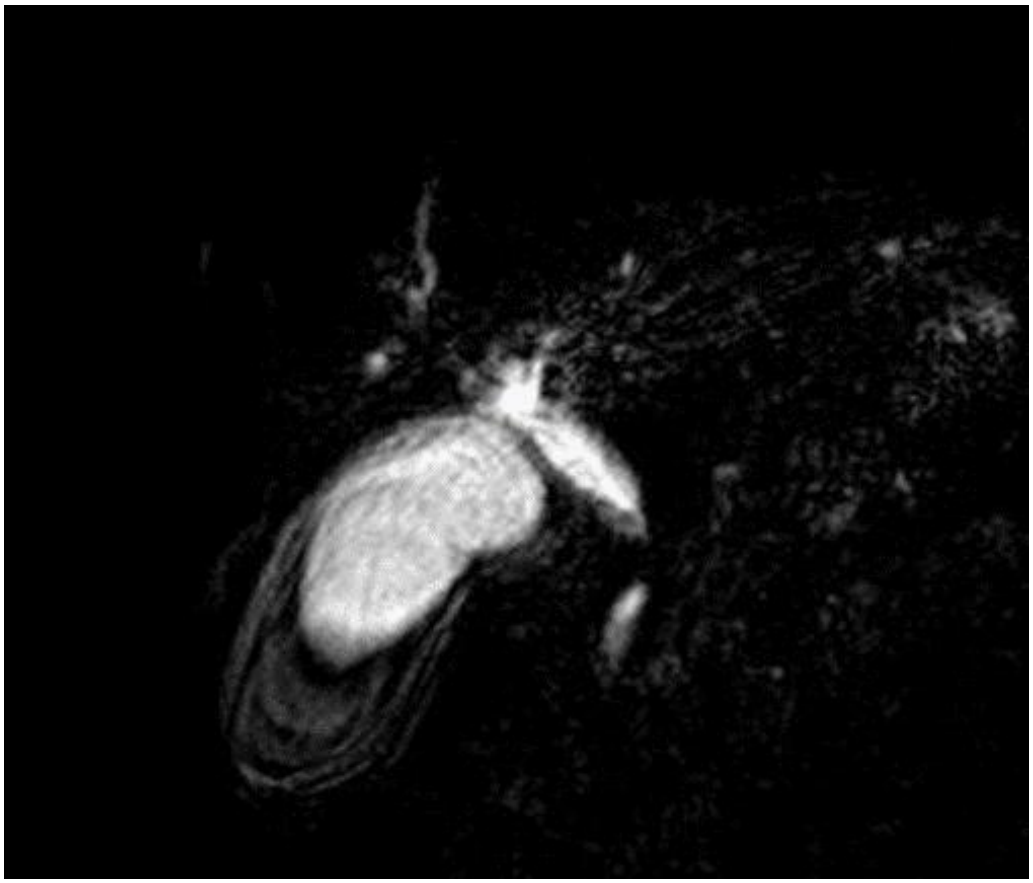


Figure (12): axial T2W image showing distened gallbladder in patient with pancreatic head tumor.



Figure(13): coronal MRCP image showing distal CBD stricture and dilated proximal part in patient with cholangiocarcinoma .



Figure(14):MRCP -3d -HR showing malignant stricture of common bile duct in patient with cholangiocarcinoma.

Discussion

In our study of (30) patients , 20(67%) were female and 10(30%) were male so in our study female more affected than male . This finding similar to study in Pakistan (13) were female(53.2%) also more affected than male(46.3%).This could be due to the fact the biliary stone are more common in female than in male.

Regarding the causes of dilated biliary tree , in our study the most common cause was choledolithiasis that was detected in (46.66%) , this percentage is approximately to study that done at in the Provincial Hospital in Rzeszow between November 2011 and April 2013 that involve 34 patient with dilated biliary tree (14) , choledolithiasis was found in 45% of cases .malignant causes in our study was 26.64%, other benign conditions was also 26.64% . while malignancy is found in 20% of same study and benign causes of biliary tract dilatation were identified in 16 % subjects . this could be to the fact that most of the patients in our sample was referred from surgery department .and increase incidence of biliary tract cancer and pancreatic cancer in older age patients.

And those with no cause identified 4 cases require further evaluation by ERCP and endoscopic ultrasound (15),(17).

and the precense of CBD stricture was in 20% of cases , about 13,32% is malignant and 6.66% is benign , compared to results of study done at india from May 2013 to May 2014(16). Total 75 patients were included . the results was 32% HAVE benign stricture and 28% malignant type , this results could be due to the smaller number of cases in our sample and also due to lesser incidence of malignancy of bile duct carcinoma in Iraq .

regarding the diameter of common bile duct , the average diameter in our study was 13 mm in those with CBD stone , comparing it with study done in National Yang-Ming University, Taipei, Taiwan at 2011, the diameter was 11.5 mm . this is because currently there are varity of normal ranges of CBD diameter that may caused by different population in different studies with varying ages and pathologies , or different approaches in CBD measurement (18) .

regarding the gallblader finding one of the prominent finding is distended gallbladder 49 99% and among patients with malignant CBD obstruction was 20% and those with CBD stone gall bladder was collapsed in 16.66% .comparing this result with the study that done at Nottingham University Hospitals at 2009 , that reveal dilated gallbladder in the majority of those with malignant causes . this finding is accepted according to the courvoisiers law which states that in the presence of a palpably enlarged gallbladder which is nontender and accompanied with mild painless jaundice, the cause is unlikely to be gallstones.

Conclusion :

1-Magnetic resonance cholangio-pancreatography is a relatively quick, accurate and non-invasive imaging modality for the assessment of patients with dilated biliary tree in ruling out potentially correctable underlying causes and reducing unnecessary invasive interventions.

2-Female more affected than male.

3-Stone was most common cause of dilated common bile duct .

4- among the malignant causes of dilated biliary tree , pancreatic head tumor was the most common malignant cause.

5-the level of obstruction is at the distal part of common bile duct in most of patients with dilated biliary tree on MRCP.

Recommendation :

1-MRCP is recommended for diagnosis of bile duct cancer , pancreatic cancer,and also for benign conditions such as inflammatory stricture.

2- MRCP is useful to assess the severity of biliary tree dilation , and the site of obstruction in obstructive conditions.

3- those with unkown cause of dilation in biliary tree on MRCP,require further evaluation using endoscopic retrograde cholangiopancreatography (ERCP).

References

(1). Wallner BK, Schumacher KA, Weidenmaier W, Friedrich JM. Dilated biliary tract: evaluation with MR cholangiography with a T2-weighted contrast-enhanced fast sequence. Radiology. 1991;181:805–808.

(2) https://www.ncbi.nlm.nih.gov/portal/utils/pageresolver.fcgi?recordid=5c31d15475f66d516a3d5f27

(3) JEFFREY S.BARKUN, PROSANTO CHAUDHURY, ALAN N.BARKUN.

Approach to the Jaundiced Patient. ACS Surgery: Principles and practice .

2006.

(4) C D BriggsM Peterson. Investigation and management of obstructive

jaundice. Surgery 25[2], 74-80. 2007.

(5)Normans.Williams,Christopherj.K.Bulstrode,P.Ronanoconnell Bailey and loves(short practice of surgery) 26 edition 2013 chapter 67 page1099

(6)FayadLM,HollandGA,BerginD,etal.FunctionalMagnatic resonance cholangiografy (Fmrc)of gallbladder and biliary tree with contrast – enhanced magnetic resonance cholangiography.JMagnReson Imaging.2003;18;449-460.

(7). Baillie J, Kimberly J. Prospective comparison of secretin-stimulated MRCP with manometry in the diagnosis of sphincter of Oddi dysfunction types II and III. Gut. 2007;56:742–744.

(8). Vitellas KM, Keogan MT, Spritzer CE, Nelson RC. MR cholangiopancreatography of bile and pancreatic duct abnormalities with emphasis on the single-shot fast spin echo technique. Radiographics. 2000;20:939–957.

(9). Thurley PD, Dhingsa R. Laparoscopic cholecystectomy: postoperative imaging. AJR Am J Roentgenol. 2008;191:794–801. doi: 10.2214/AJR.07.3485.

(10). Park MS, Yu JS, Lee JH, Kim KW. Value of manganese-enhanced T1- and T2-weighted MR cholangiography for differentiating cystic parenchymal lesions from cystic abnormalities which communicate with bile ducts.Yonsei Med J. 2007;48:1072–1074.

(11). Halefoglu AM. Magnetic resonance cholangiopancreatography: a useful tool in the evaluation of pancreatic and biliary disorders. World J Gastroenterol2007;13:2529–2534.

(12) Irie H, Honda H, Kuroiwa T, Pitfalls in MR cholangiopancreatographic interpretation. RadioGraphics2001.

(13)Ali M, Ahmed I, Sattar A , Akhtar M et al. Diagnostic accuracy of magnetic resonance cholangio-pancreatography in evaluation of obstructive jaundice. J Pak Med Assoc.2012 ;62(10):1053-6

(14) Radosław Ramotowski,Diagnostics of biliary dilatation by means of magnetic resonance cholangiopancreatography. 2014; 79: 315–322. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4167505/

(15) Douglas G. Adler Todd H. Baron,the role of ERCP in diseases of the biliary tract and the pancreas.2005,04,015.

https://www.giejournal.org/article/S0016-5107(05)01856-0/fulltext

(16) Sunita Purohit, Role of MRCP in Differentiation of Benign and MalignantCausesofBiliaryObstruction,2015 nov 9(11).

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4668504/

(17) Bruno, Mauro MD*; Brizzi, Rosario F. MD Unexplained Common Bile Duct Dilatation With Normal Serum Liver Enzymes: Diagnostic Yield of Endoscopic Ultrasound and Follow-up of This Condition

https://journals.lww.com/jcge/Abstract/2014/09000/Unexplained_Common_Bile_Duct_Dilatation_With.2.aspx

(18) Ching-Ruei Hung1, Ay-Chiao Huang, measurement of common bile duct by MRCP. J Radiol Sci 2011; 36: 93-98

(19)
Fitzgerald JE, White MJ, Lobo DN (2009) Courvoisier's gallbladder: law or sign? World J Surg 33(4):886–91. https://doi.org/10.1007/s00268-008-9908-y