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Magnetic resonance cholangiopancreatography in differentiating benign and malignant biliary obstruction

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Abstract

Background: Biliary obstruction is caused by either inflammatory or malignant stricture. The imaging evaluation of patients with biliary stricture has traditionally included US, CT and direct cholangiography. MRCP has gained wide acceptance from clinicians as an accurate and noninvasive alternative tool for evaluating pancreaticobiliary ductal abnormalities, and succeeded to replace diagnostic ERCP and make it obsolete.

Aim of the work: The evaluation the role of Magnetic Resonance Cholangiopancreatography in differentiating benign and malignant biliary obstruction**.**

Patients and Methods: This study included 25 patients with clinical picture suggestive of biliary obstruction. They were 13 males and 12 females, their aged ranged from 12 to 80 years. The patients were referred to Diagnostic Radiology and Medical Imaging Department, at Tanta University Hospital during a period from June 2021 to October 2022. Some patient's study obtained from liver institute and private centers. All patients underwent MRCP on 1.5 Tesla MRI scanner.

Results: The overall accuracy of MRCP in detection of biliary dilatation and level of obstruction was 100%. However, the cause of obstruction was correctly diagnosed in 23 out of 25 patients with 92% overall accuracy. Diagnostic accuracy of conventional MRI, 2D&3D MRCP images and combined conventional T2MRI & MRCP were 84%, 80% & 92% respectively. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRCP were 90%, 93.33%, 90%, 93.33% and 92% respectively

Conclusion: MRCP is a superior modality, exhibiting higher sensitivity, specificity and diagnostic accuracy for evaluating both malignant and benign conditions in patients with biliary obstruction.

Keywords: Cholangiopancreatography, malignant biliary, magnetic resonance

Introduction

Differentiating benign and malignant biliary strictures is a challenging and important clinical scenario. The typical presentation is indolent and involves elevation of liver enzymes, constitutional symptoms and obstructive jaundice with or without superimposed or recurrent cholangitis [1].

While the most common causes of biliary strictures are malignant, including cholangiocarcinoma and pancreatic adenocarcinoma, benign strictures encompass a wide spectrum of etiologies including iatrogenic, autoimmune, infectious, inflammatory and congenital. Imaging plays a crucial role in evaluating strictures, characterizing their extent, and providing clues to the ultimate source of biliary obstruction [4].

Various techniques are available for imaging of the biliary tree such as ultrasonography, intravenous cholangiography, drip-infusion CT cholangiography, endoscopic retrograde cholangio-pancreatography (ERCP), intraoperative cholangiography and magnetic resonance cholangio-pancreatography (MRCP) [5].

Intravenous cholangiography does not provide a detailed visualization of the biliary tree. ERCP and intraoperative cholangiography are highly accurate but invasive procedures [5].

While ultrasound is a good screening tool for biliary ductal dilatation, it is limited by a poor negative predictive value. Magnetic resonance cholangio-pancreatography is more than 95% sensitive and specific for detecting biliary strictures with the benefit of precise anatomic localization [4].

Magnetic resonance cholangiopancreatography is the preferred non-invasive imaging modality for anatomical and pathological evaluation of the pancreaticobiliary duct system, as it is safe and not associated with ionizing radiation. High resolution cross-sectional, two dimensional and three dimensional (3D) projection images provide an excellent detailed anatomy [6].

When compared to ERCP, MRCP is a lower cost diagnostic examination that does not require exogenous contrast material, can often be performed without sedation or analgesia, and has no risk of post-procedural pancreatitis. Unlike ERCP, MRCP also allows direct visualization of hepatic and pancreatic parenchyma and surrounding structures [6, 7].

Magnetic resonance cholangio-pancreatography (MRCP) is a promising approach for biliary and pancreatic duct imaging, which uses MR imaging to visualize fluid in the biliary and pancreatic ducts as a high signal intensity on heavily T2-weighted sequences. This technique is especially useful in neoplastic diseases of pancreatic or biliary ducts [8].

Furthermore, when MRCP is performed as a part of full abdominal examination, it can provide a one-step evaluation of nature and site of ductal disease and the extent and stage of any underlying tumor, including detection of any associated adenopathy or liver metastasis. As MRCP is a noninvasive technique, which is free from complications and of comparable accuracy to ERCP, its role needs to be evaluated in various causes of biliary obstruction [1].

Aim of the work

To evaluate the role of Magnetic Resonance Cholangiopancreatography in differentiating benign and malignant biliary obstruction.

Patients and Methods

This study included 25 patients with clinical picture and laboratory findings suggestive of biliary obstruction. They were 13 males and 12 females, their age ranged from 12 to 80 years. The patients were referred to Diagnostic Radiology and Medical Imaging Department, at Tanta University Hospital during a period from June 2021 to October 2022. All patients underwent MRCP on 1.5 Tesla MRI scanner.

Inclusion criteria

1. Patients with clinical and laboratory findings suggestive of biliary obstruction such as: jaundice, pruritus, change in color of the urine or stool as well as elevated serum direct & total bilirubin (>2 mg/dl) and/or alkaline phosphatase (>290 U/L).
2. Patients with biliary tract pathologies detected by abdominal ultrasound.

Exclusion criteria

Patients who had contraindications to MRI examination such as

1. Patients with cochlear implants or metallic surgical aneurysm clips.
2. Cardiac pacemaker.
3. Metallic foreign body in eye.
4. Patients with bad general condition who cannot remain still or cannot comply with breath hold instructions.
5. Claustrophobic patients.

All selected patients were subjected to the following

Clinical assessment including

Clinical history: age, sex, symptoms and signs related to biliary duct disease e.g. right upper quadrant pain, jaundice, dyspepsia, pruritus and color change of the urine or stool.

Laboratory assessment including

Laboratory diagnosis of cholestatic jaundice was based on raised liver function tests including total bilirubin, direct bilirubin and/or alkaline phosphatase.

Available tumor markers (CA19-9, CEA, AFP).

Imaging Assessment including

1. Abdominal ultrasound was done for all cases.
2. MRCP was performed for all patients on 1.5 tesla MRI scanner.
3. Dynamic MRI of abdomen & abdominal CT scan was done for 6 patients.

The final diagnosis was based on either surgical findings, histopathology of resected specimen or ERCP findings.

MRCP technique

Patient preparation

- Patients were instructed to fast 4-6 hours prior to examination to promote GB filling, decrease bowel peristalsis and minimize any fluid signal retained within stomach or duodenum that may interfere with biliary tree imaging.
- All patients were informed about the MRCP examination time, the value of remaining motionless during examination and the importance of holding their breath well at certain points.
- As in other MRI examination, patients were asked about any history of cardiac pacemaker, metallic aneurysmal clips, metallic prosthesis and asked to remove any ferromagnetic objects in their clothes that interfere with magnetic field of MRI unit, degrade image quality and are potentially hazardous to the patients.

Patient position

All patients lied supine on scanner table with their arms raised above their heads and their feet entering the magnet bore first. Respiratory triggering belt was placed around upper abdomen to acquire respiratory triggered sequences with meticulous care to ensure it yields a good respiratory monitoring trace on scanner screen. A phased array surface body coil was placed to obtain high signal to noise ratio and high spatial resolution.

MRCP protocol

- This study was performed using 1.5 Tesla closed MRI scanner (Vantage Titan, Toshiba Medical Systems, Japan).
- All patients were subjected to MRCP study which consists of image acquisition followed by image processing and analysis.

Image acquisition

The entire MR examination was performed under the guidance of a radiologist to determine the location of the MRCP slabs that properly fit the entire length of the common bile duct and intrahepatic ducts.

- First a multiplanar fast field echo (FFE) localizer upon which the pulse sequences were planned starting from the diaphragm to the lower border of both kidneys with slice thickness 9 mm.
- Then conventional axial and coronal T2 weighted FSE images of the upper abdomen

The axial T_2 weighted MR images of the upper abdomen were obtained first before MRCP as they served as a guide to optimally localize the biliary system and to determine the correct obliquity of the coronal oblique sections of MRCP images. The angle of MRCP examination was chosen from the cut at which the CBD or the region of suspected lesion tend to appear.

Thick slab breath hold two dimensional (2D) single shot heavily T_2 weighted sequences

The angle of the coronal image could be changed several times and thick coronal slabs were obtained at different angles from horizontal plane pass through the head of pancreas to ensure including the distal part of the pancreatico-biliary tract in all images. The first slab was acquired at the direct coronal plane and about 4-5 slabs with different degree of obliquity were acquired on either side of the mid horizontal plane.

Thin slab Respiratory triggered three-dimensional (3D) MR Cholangiopancreatography

Multi-section MRCP was performed with respiratory triggering in order to reduce respiratory motion artifacts. The data were acquired between successive respiratory cycles (i.e. from the end of the expiration to the beginning of the following inspiration). The use of respiratory triggering increased the actual scan time depending on the patient's breathing pattern and respiration rate. The images were obtained in the right anterior oblique plane parallel to the longitudinal axis of the biliary tree. MRCP parameters are shown in (Table 1) [9].

Image processing

The data obtained after scanning were reviewed on workstation with 2D and 3D capability with multiple editing options:

- Image reconstruction and post-processing of the MRCP source images was performed using a maximum intensity projection (MIP) image produced in the coronal plane. Then, the technician edited and removed unnecessary anatomical details from the image by using a manual cutting tool at the workstation to form one or few coronal MIP images showing the entire biliary system anatomy.
- Three-dimensional models of the common bile duct and both hepatic ducts were generated by using a volume-rendering (VR) technique and visual enhancement was achieved by means of artificial color assignment to the re-constructed images.

Image analysis

All available images including 2D and 3D MRCP images and their individual source images were initially reviewed for image quality and evaluated for:

- The degree of dilatation of the intra-hepatic and extra-hepatic bile ducts as well as pancreatic duct.
- The level of biliary obstruction
- The morphological aspect at the obstruction site.

Possible cause of biliary obstruction (choledocholithiasis, tumor, post-operative and the presence of lymphadenopathy or metastases).

Table 1: MRCP parameters [9].

Scanning parameters	2D T2 SSFSE	3D heavy T2 FAT SAT	2D T2 SSFSE	Thick slab heavy T2
TE (ms)	120	840	120	1200
TR (ms)	1050	1860	1050	3120
FOV (mm)	40.0	32.0	40.0	34.0
Slice thickness (mm)	6.0	3.0	4.0	40.0
Spacing	0.0	0.0	0.0	0.0
Freq	256	384	256	320
Phase	224	160	224	256
NEX	1.00	2.00	1.00	1.00
Phase FOV	0.90	1.00	0.90	1.00
Scan time (min)	1:39	2:33	1:11	0:02 per slab (30 to 40 sec)
Acquisition Plane	Axial	Coronal oblique	Coronal	Coronal
Bandwidth (Hz/pixel)	62.50	62.50	62.50	62.50
Flip angle	150	180	150	180

Statistical analysis

Data was analyzed by IBM SPSS 20.0 version software. Collected data were spread on excel sheet and prepared master chart. Through the master chart tables and graphs were constructed. For quantitative measures Data were expressed as mean, standard deviation (SD), Using sample t test to compare the mean values between two variables for statistical significant. And for qualitative data analysis, chi square test was applied for statistical significant. $p \leq 0.05$ was considerable statistically significant for all comparisons.

Results

This study was carried out on 25 patients suspected with biliary obstruction, 13 males and 12 females. Their ages ranged from 12-80 years with a mean ± SD of 47.80 ± 19.51.

The most common cause of benign biliary obstruction was calcular obstruction, while the most common cause of malignant obstruction was cholangiocarcinoma (Table 2).

Table 2: Distribution of the studied cases according to cause of biliary obstruction (n = 25)

Items	No.	%
Benign	15	60.0
Calcular obstruction	6	24.0
Choledochal cyst	4	16.0
Benign stricture	3	12.0
Post cholecystectomy biliary obstruction	2	8.0
Malignant	10	40.0
Cholangiocarcinoma	3	12.0
Pancreatic head carcinoma	2	8.0
Periampullary carcinoma	2	8.0
Liver metastases	1	4.0
Pathological porta hepatis nodes	1	4.0
Duodenal carcinoma	1	4.0

The most common level of biliary obstruction was at the distal end of common bile duct (Figure 1).

Figure (2) shows that combination of conventional T2 MR Image and 2D&3D MRCP images significantly improve diagnostic accuracy for differentiating benign and malignant biliary obstruction than using of conventional MRI or 2D&3D MRCP images alone.

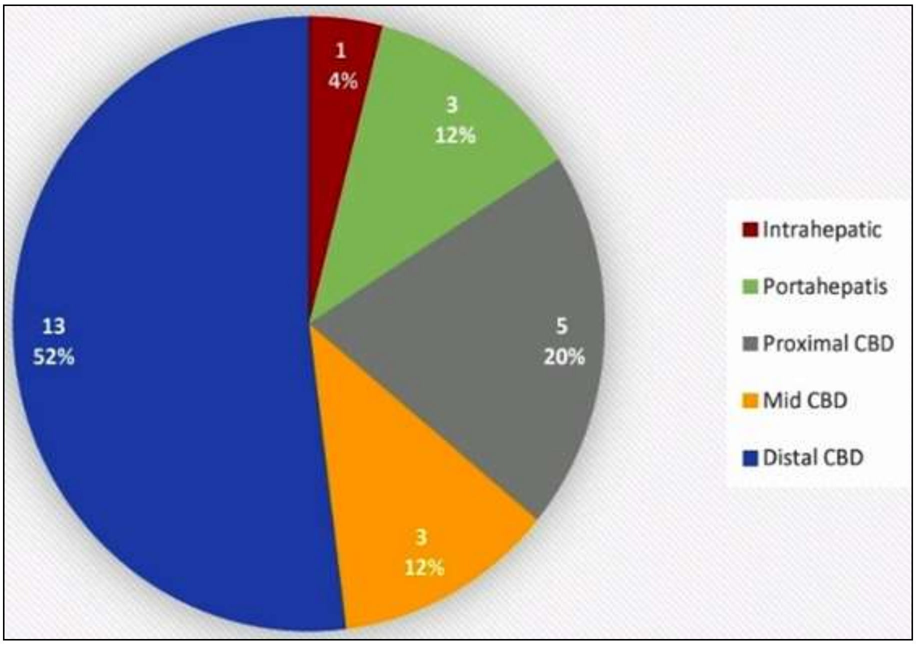


Fig 1: Level of biliary obstruction by MRCP in 25 cases

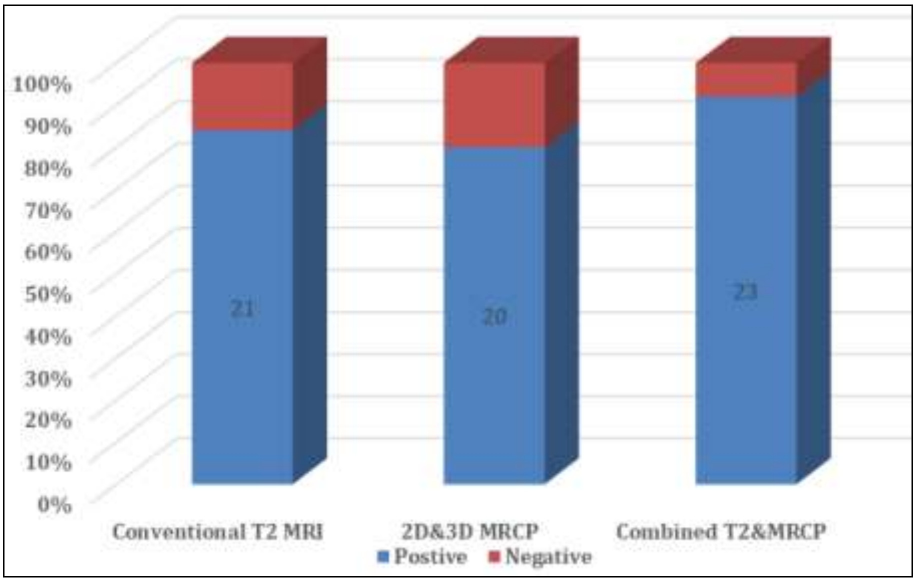


Fig 2: Diagnostic value of conventional T2 MRI, 2D & 3D MRCP sequences and combined T2 & MRCP sequences in 25 cases of biliary obstruction

Table (3) shows that pitfalls were more common in breath hold thick slab 2D MRCP sequence than respiratory triggered thin slab 3D MRCP. 6 of 25 cases (24%) with pitfalls distributed in breath hold thick slab 2D MRCP as follow: 2 cases with motion artifact, 2 cases with partial volume artifact, one case with duodenal fluid and one case with ascitic fluid, while 2 of 25 cases (8%) with pitfalls distributed in respiratory triggered thin slab 3D MRCP as follow: one case with duodenal fluid and one case with ascitic fluid.

As regard to final diagnosis, the MRCP results were correlated with other imaging studies, ERCP, surgical and/or histopathological data. It was found that 14 out of 15 cases were correctly diagnosed as benign lesions and 9 out of 10 cases were correctly diagnosed as malignant lesions, while one case misdiagnosed as benign lesion and one case misdiagnosed as malignant lesion. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRCP were 90%, 93.33%, 90%, 93.33% and 92% respectively (Table 4).

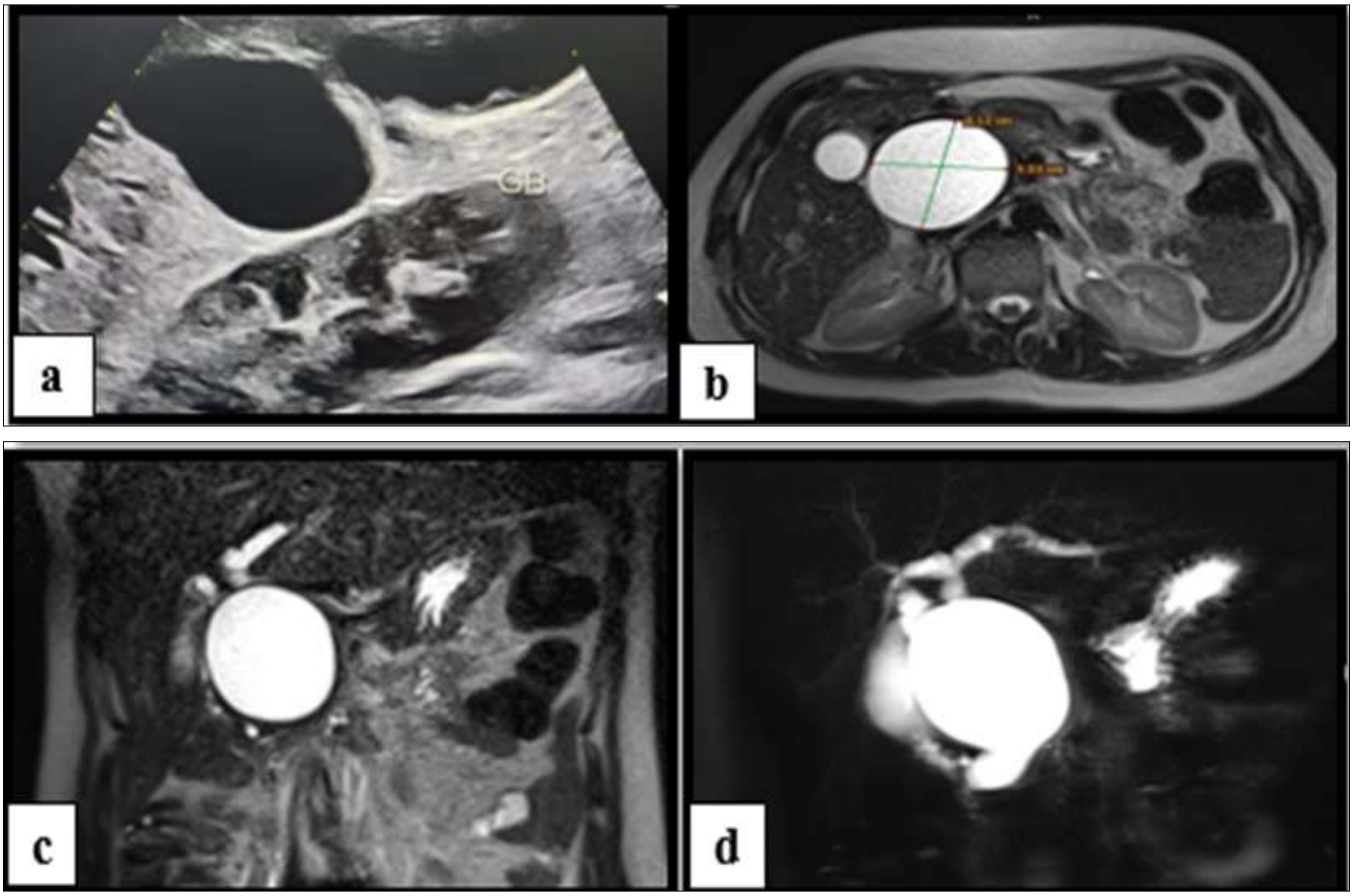
Table 3: Distribution of pitfalls in 2D & 3D MRCP sequences in the studied cases (n = 25)

Pitfalls	Breath hold thick slab 2D MRCP	Respiratory triggered thin slab 3D MRCP
Technical pitfalls		
Motion artifact	2	0
Partial volume artifact	2	0
Extra-ductal pitfalls		
Duodenal fluid	1	1
Ascitic fluid	1	1
Total %	6 24%	2 8%

Table 4: Sensitivity, specificity and accuracy of MRCP

	Final diagnosis				Sensitivity	Specificity	PPV	NPV	Accuracy
	Benign (n = 15)		Malignant (n = 10)						
	No.	%	No.	%					
MRCP									
Benign	14	93.3	1	10.0	90.0	93.33	90.0	93.33	92.0
Malignant	1	6.7	9	90.0					
χ^2 (^{FE}p)	17.361*(<0.001*)								

χ^2: Chi square test FE: Fisher Exact p: p value for association between different categories *: Statistically significant at $p \leq 0.05$.



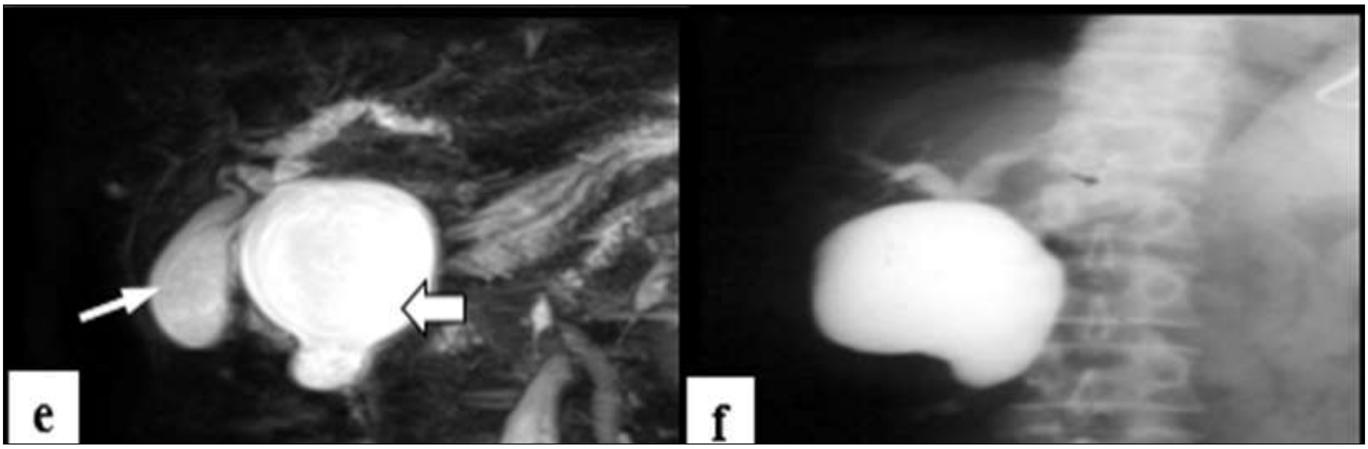
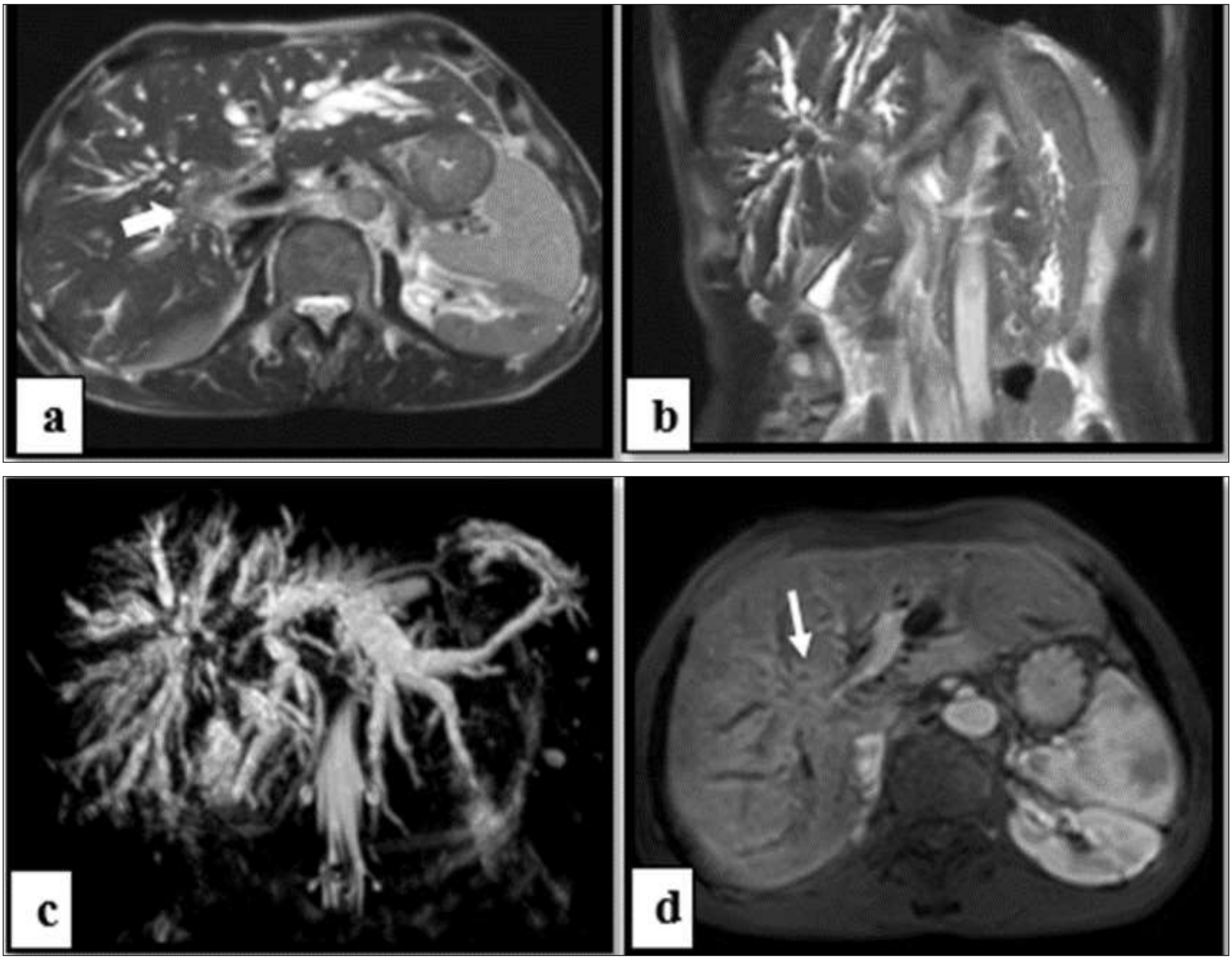


Fig 3: Female patient aged 25 years complaining from right upper quadrant pain and jaundice. Abdominal ultrasound (a) shows non vascular cystic structure at porta hepatis region that communicates with bile duct and is separate from gall bladder. Axial T2 weighted MR image (b), Coronal T2 weighted MR image (c), Coronal oblique 2D MRCP (d) & Coronal oblique 3D MRCP (e) show large cystic dilatation of the entire of CBD (thick arrow) about 5.8X6.2 cm in maximum diameter associated with mild dilatation of CHD, right and left main hepatic duct and normal distended gall bladder (thin arrow). Intraoperative cholangiography (f) shows cystic dilatation of CBD associated with mildly dilated CHD, right and left main hepatic ducts.

Diagnosis

Congenital biliary malformation according to Todani classification …Choledochal cyst type I.



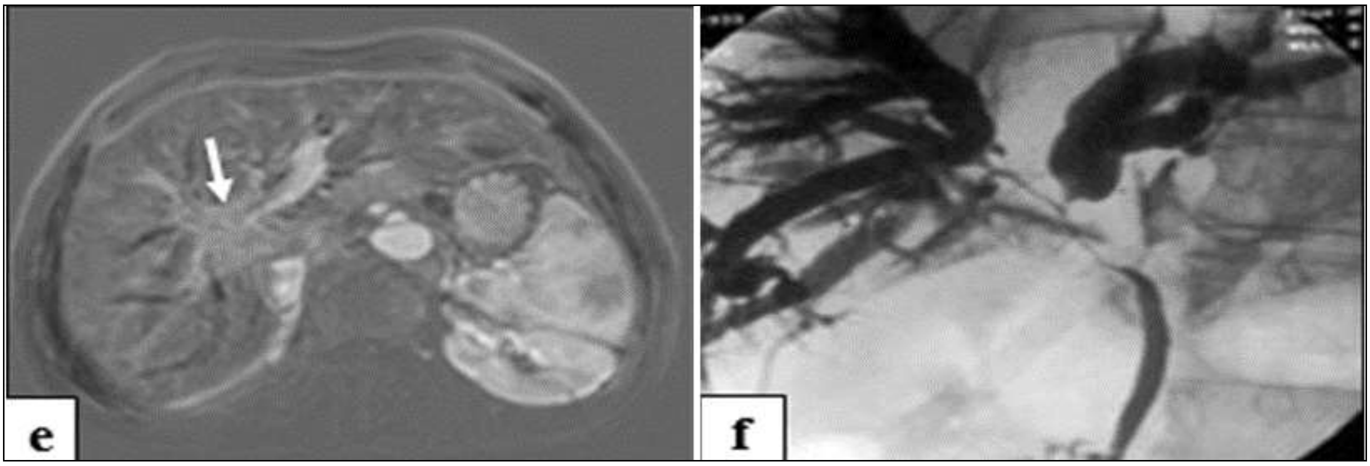
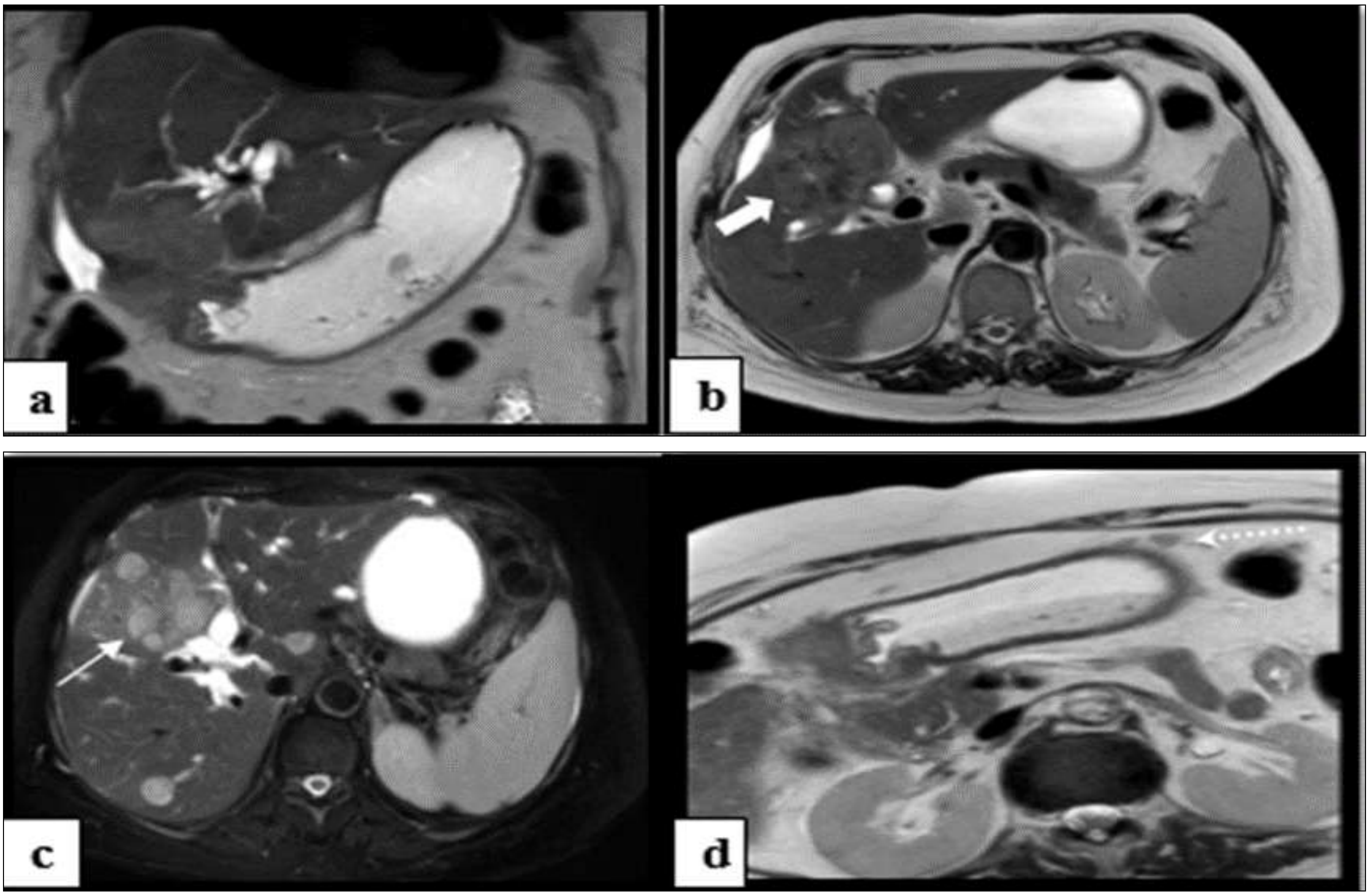


Fig 4: Male patient aged 65 years old complaining with right upper abdominal pain, weight loss and rapidly progressive jaundice. Axial T2 weighted MR image (a) & Coronal T2 weighted MR image (b) show an ill-defined hepatic hilar area displaying intermediate T2 signal is seen implicating confluence of the right and left hepatic duct and CHD (thick arrow) with subsequent intrahepatic bile ducts dilatation more at left side while, CBD shows normal caliber. Coronal oblique 3D MIP-MRCP (c) shows moderate right lobar and marked left lobar bile ducts dilatation (non-communicating right and left hepatic duct) while, CBD shows normal caliber. Axial T1 post contrast portal phase (d) & subtraction image (e) show faint enhancement of the ill-defined hilar hepatic area (thin arrow) with attenuation of the proximal end of left portal vein and non-visualized right portal vein likely thrombosed. Percutaneous cholangiogram (f) shows sever stricture at hepatic confluence with marked intrahepatic bile ducts dilatation with loss of union between the right & left main hepatic ducts.

Diagnosis

Hilar cholangiocarcinoma (Klatskin tumor type IV)



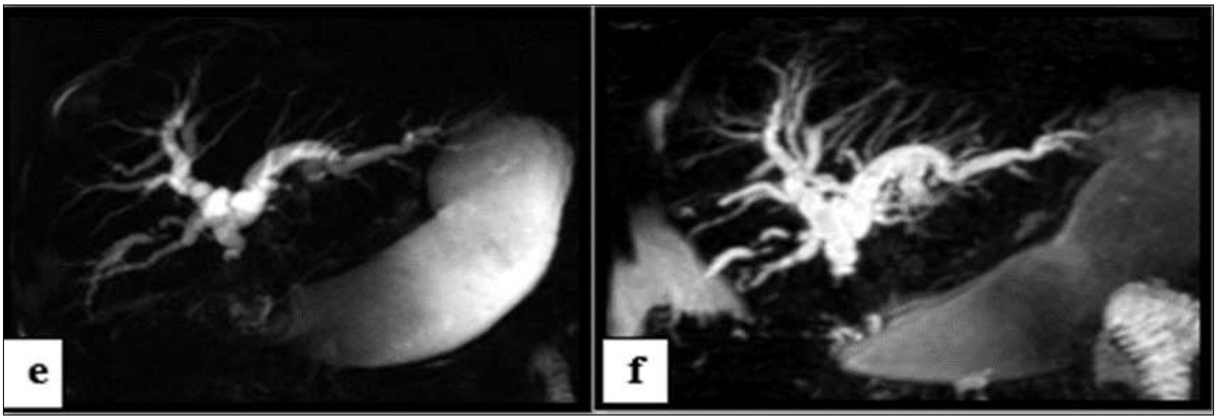


Fig 5: Female patient aged 68 years old with history of duodenal carcinoma presented with progressive jaundice. Coronal T2 weighted MR image (a), Axial T2 weighted MR image (b), Axial T2WI-STIR (c) & Axial T2WI-zoom (d) show large ill-defined irregular shaped mass is seen infiltrating GB bed, related liver parenchyma, gastric pylorus and duodenum (proximal to duodenal papilla) measuring about (7.5x6.5cm) in its maximum dimension and displays intermediate T2 signal (thick arrow) & faintly high STIR signal (thin arrow). There is also few small discrete hepatic focal lesions (thin arrow) and multiple small peritoneal soft tissue nodules (dashed arrow) likely metastasis. Coronal oblique 2D MRCP (e) & Coronal oblique 3D MIP-MRCP (f) show moderate dilatation of intrahepatic bile ducts, CHD and proximal CBD which shows abrupt bile signal termination. Mid and distal portion of CBD are not visualized and Pancreatic duct is not dilated

Diagnosis: Malignant biliary obstruction due to infiltrative duodenal carcinoma.

Discussion

MRCP is a crucial noninvasive imaging modality for preoperative evaluation of obstructive jaundice patients, replacing invasive ERCP and PTC. It is the gold standard technique in biliary tract imaging & helping surgeons in accurate therapeutic planning [10].

Differentiating benign and malignant biliary obstructive lesions is clinically difficult alone. Our prospective controlled study confirmed that MRCP can distinguish clearly between benign and malignant biliary diseases. Depending on morphological features we found that abrupt caliber change, irregular margin, long segment and mass presence were common with malignant lesions. While, benign lesions were smooth and gradual tapering. This is similar to Saluja *et al.* [11] and Yu *et al.* [12].

Regarding analysis of MRCP findings, it was noted that 6 (24%) out of 25 patients had CBD stones representing the main cause of benign biliary obstruction, with a substantial majority of CBD stones were located in the distal portion of the CBD and majority of patients had a solitary CBD stone. Our findings are similar to the study of Enaba *et al.* [14]

Until now, there has been little information about the value of MRCP in diagnosing choledochal cysts (14). In our study, we were able to depict four cases of choledochal cyst in different age group presenting with jaundice and abdominal pain. MRCP was able to display the anomaly, as well as, determine the type according to Todani′s classification which is required for planning surgery and postoperative control.

MRCP displayed a great value in diagnosis of cholangiocarcinoma which is, the most common malignant tumor in our study (3 cases) and could classified it according to its morphology: mass forming type (one case) and periductal infiltrative type (two cases) as well as another type intraductal growth which not included in our study. And according to its site: intrahepatic (One case), perihilar (One case) & extrahepatic (One case). This is in agreement with the study of Sakran *et al.* [15].

This study showed that the most prevalent site of obstruction was at the distal end of the CBD, affecting 13 cases (52%). These data are in line with Saxena *et al.* [16]. While, the results of Kushwah *et al.* [17] were not similar with ours.

Parashari *et al.* [18] agreed with our findings regarding MRCP accurately identified ductal dilatation and localized the obstruction level in all cases, achieving a perfect 100% accuracy. In 23 cases, it determined the cause of obstruction, yielding a robust 92% overall accuracy with two cases were misdiagnosed (a case of peri-ampullary carcinoma because the mass not detected & the stricture morphology suggesting a benign stricture and a case of benign stricture was misdiagnosed as pancreatic head cancer as it had a pancreatic mass with dilated CBD & pancreatic duct). This is in alignment with the study of Shabanikia *et al*. [19], in which MRCP misdiagnosed a post-surgical stricture to be a malignant stricture.

Regarding pitfalls in MR imaging, on results of many published articles (20, 21) agreed with our findings. Our study found that pitfalls in MR imaging, particularly in breath hold thick slab 2D MRCP sequences, can lead to underestimation of pathology. These challenges are crucial for radiologists and clinicians to interpret MRCP images, as they affect the accuracy and reliability of diagnostic assessments, ensuring more precise evaluations of the pancreaticobiliary ductal system.

As regard to final diagnosis, our findings align with multiple previous studies [16, 19, 20]. the MRCP results were correlated with other imaging studies, ERCP, surgical and/or histopathological data and it was found to yield sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 90%, 93.33%, 90%, 93.33%, and 92% respectively, denoting an overall excellent diagnostic performance.

Despite its advantages, MRCP faces limitations in our study such as high cost, inability to offer therapeutic intervention, image quality degradation due to obesity, ascites, GB collections and breath hold technique issues.

Conclusion

MRCP is a non-invasive, contrast-free imaging modality provide high diagnostic accuracy with no substantial complications make it an ideal choice for evaluating patients with biliary obstructive diseases and providing the basis for the suitable further therapeutic procedures. The benign & malignant nature of biliary obstruction can be determined by

MRCP through the observation of stricture margins, length and dilatation.

Abbreviations
2D: Two-dimensional; 3D: Three-dimensional; AFP: Alpha fetoprotein; CBD: Common bile duct; CEA: Carcinoembryonic antigen; CHD: Common hepatic duct; CT: Computed tomography; ERCP: Endoscopic retrograde cholangiopancreatography; FFE: fast field echo; MIP: maximum intensity projection; MRCP Magnetic resonance cholangiopancreatography; MRI: Magnetic resonance imaging; PTC: Percutaneous transhepatic cholangiography; VR: volume-rendering;

Conflict of Interest
Not available

Financial Support
Not available

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