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Prospective Evaluation of MRCP as A Non-Invasive Diagnostic Tool in Patient with Suspected Obstructive Biliopathy

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Abstract		Original Research Article

Diseases of the biliary tree and the pancreas are common in India and worldwide. Causes of bile duct obstruction may be benign or malignant. Benign causes may be due to intraluminal causes e.g. Choledocholithiasis, Haemobilia or parasites. Non- invasive imaging modalities of biliary system include USG, CT. Invasive methods include direct cholangiographic methods like ERCP, Percutaneous Transhepatic Cholangiography (PTC) and Intraoperative Cholangiography. USG is the primary screening modality. This prospective study was done to evaluate the role of MRCP as a non-invasive diagnostic tool in patients with suspected obstructive biliopathies and to compare and correlate the MRCP findings with those of other modalities. MRCP was comparable with Direct Cholangiography in identifying the level of block in 57 of 60 cases (95%) MRCP showed high sensitivity (100%) and diagnostic accuracy (96.29%) in identifying the level of block. MRCP is not only comparable with direct cholangiography in its diagnostic ability, but it has the tremendous advantage of being noninvasive. MRCP is still an evolving technique, it has established itself as clinically useful noninvasive investigation and comparable with direct cholangiography for the evaluation of various pancreatic or biliary ductal diseases.
Keywords: biliary tree, pancreas, Choledocholithiasis, Haemobilia, MRCP.

INTRODUCTION

Diseases of the biliary tree and the pancreas are common in India and worldwide. Causes of bile duct obstruction may be benign or malignant. Benign causes may be due to intraluminal causes e.g. Choledocholithiasis, Haemobilia or parasites. Benign causes originating from the wall include infection or inflammation of the bile ducts e.g. Primary Sclerosing Cholangitis, AIDS cholangiopathy, Post-Surgical Stricture and Hepatic Artery Chemotherapy. Extraluminal causes include acute and chronic pancreatitis, Ampullary Stenosis, lymph node compression or vascular compression e.g. Portal cavernoma or aneurysm. Malignant causes may be intraluminal e.g. Cholangiocarcinoma or Carcinoma of the Gall Bladder. Extraluminal causes include Carcinoma of the head of pancreas, Duodenal or Ampullary Carcinoma, or metastatic disease. Congenital causes include Biliary Atresia, Choledochal Cyst or Caroli's Disease [1].

Clinical suspicion of biliary obstruction is by signs and symptoms of jaundice (Serum Bilirubin > 2mg/dl), pale stools, dark frothy urine, pruritis and hepatomegaly. Biochemical tests show increased serum bilirubin especially of the direct conjugated form, greater elevation of serum alkaline phosphatase and gamma glutamyl transpeptidase (GGTP) compared with Aminotransferases. Management of biliary obstruction may be palliative or definitive and includes percutaneous, endoscopic or surgical methods. Prior to any procedure, imaging of biliary tree is required to confirm the presence of obstruction and to accurately localize the site of obstruction. Identification of the cause of obstruction and its differentiation into benign and malignant is essential.

Non- invasive imaging modalities of biliary system include sonography (USG) or computed tomography (CT). Invasive methods include direct cholangiographic methods like endoscopic retrograde cholangiopancreatography (ERCP), Percutaneous Transhepatic Cholangiography (PTC) and Intraoperative Cholangiography. USG is the primary

screening modality with advantages of rapidity, low cost, free of radiation hazards and visualization of adjacent structures. In diagnosis of CBD stones, USG has specificity > 90% but sensitivity of 20 – 80% [2]. The chief disadvantage of USG is that the procedure is highly operator dependent. Calculus detection rate is also influenced by patient factors such as the number, size and site of calculi, patient's body habitus and the presence of overlying bowel gases. Endoscopic USG avoids some of these problems by placing transducer close to the duct and can be extremely sensitive in detecting stones but the expertise is not widely available. EUS is a minimally invasive procedure with minimal morbidity and mortality. It requires general anesthesia and cannot be performed in patient with previous gastric surgery. Also, it does not allow therapeutic approach other than sphincterotomy.

CT is an important means of evaluating biliary obstruction. Like USG it permits measurement of caliber of the biliary tree. It is capable of detecting space occupying lesions as small as 5 mm. when compared with USG it is not operator dependent, provides technically superior images in obese patients and in whom biliary tract is obscured by gases [1]. Due to more complete delineation of biliary tree, CT may be more useful than USG for defining the site and etiology of obstruction [3]. CT can differentiate benign from malignant obstruction and can provide guidance for biopsy and staging of malignancies. Helical CT cholangiography has been described which offers single breathhold acquisition of data and the ability to perform 3D MIP (Maximum intensity projection) and multiplanar reconstructions. The technique is limited however in patients with hyperbilirubinemia and carries the risk of reactions to intravenous iodinated contrast media. In addition, ionizing radiation may preclude imaging in pregnant patients [4]. ERCP is currently the gold standard for the diagnosis of pancreatic and biliary ductal pathology. ERCP has the advantages of direct pancreatic duct visualization, inspection of upper gastrointestinal tract (GIT) and ampulla with permission of biopsy of ampullary lesions.

In addition, ERCP has therapeutic potential in form of endoscopic sphincterotomy or stent placement. ERCP is highly operator dependent with unsuccessful cannulation of CBD / pancreatic duct (PD) in 3-9 % of cases. The rate of success varies from 70-97 % and increases with experience of operator. There is partial or no opacification of ducts proximal to a severe or complete obstruction. It is an invasive procedure with a morbidity rate of 1-7 % and a mortality rate of 0.2-1% [5]. Complications include development of sepsis in the obstructed system, pancreatitis, gastric / duodenal perforation and bleeding.

Magnetic resonance cholangiopancreatography (MRCP) is the newest modality for biliary and pancreatic duct imaging. It represents the most popular

current clinical application of MR hydrography (*i.e.* MR imaging of slow velocity / static body fluids). MRCP uses MR imaging to visualize fluid in the biliary and pancreatic ducts as high signal intensity on heavily T 2 weighted (T2W) sequences. The long T2 value of fluid allows duct to be imaged in their basal state without distension by exogenous contrast [6]. MRCP is non-invasive and hence free from complications. It does not require deep sedation. It neither depends on the skill of the operator in cannulation nor on the anatomical relationship of the PD and the CBD to each other. It can demonstrate the stenosed portion of the biliary duct in a single image. MRCP can help to delineate the biliary tract in proximal obstructions in which ERCP may not be successful and in distal obstructions in which PTC may be of limited value. Its technique does not depend on the site of biliary obstruction as in PTC where puncture of both lobes is required in unilateral obstruction or obstruction at the level of junction of right and left hepatic ducts.

Another important advantage of MRCP is that ductal depiction can be entirely selective so that only the ductal content is depicted, or semi-selective so that ductal content is depicted with the surrounding tissue. This technique is especially useful in neoplastic diseases of pancreatic or biliary ducts [7]. In contrast, conventional cholangiography directly depicts only the duct lumen and periductal pathology is only indirectly inferred from these images [8]. Initial reports of MRCP have appeared in literature and the results are quite encouraging. Guibaud *et al.*, in 1995, using 2D FSE imaging in coronal, axial and oblique planes reported that MRCP can diagnose biliary obstruction with a sensitivity of 91% and specificity of 100% and an accuracy of 94%, and in choledocholithiasis has a sensitivity of 81%, specificity of 98 % and accuracy of 97 % [5]. In 1999, Verghese *et al.*, performed MRCP initially using shoulder coil and a phased array torso coil. Heavily T2 weighted 2D FSE technique was used. They acquired 19 contiguous coronal images of 3 mm thickness through biliary tract with application of frequency selective fat suppression. They reported sensitivity, specificity and diagnostic accuracy of 91%, 98% and 97% respectively in diagnosis of choledocholithiasis. In case of neoplastic etiology, the level of obstruction was identified correctly in 84-88% and site of underlying tumour was identified in 84-91% of cases [7].

The major disadvantage of MRCP compared with conventional cholangiography is a somewhat lower spatial resolution, such that MRCP continues to be partially limited in the assessment of fine details such as subtle small duct changes of sclerosing cholangitis and side branch changes of chronic pancreatitis. This is also due to lack of duct distension during MRCP compared with direct introduction of contrast in the channels during direct cholangiography [9]. The limited spatial resolution of MRCP makes

differentiation between benign and malignant strictures difficult. MRCP with a Half Fourier Singe Shot Spin Echo sequence has a maximum resolution of 1 mm, which is not considered sufficient for pediatric procedures and evaluation of these patients, especially infants remain a diagnostic problem. Also, MIP reconstructed images may completely obscure small filling defects due to the partial volume effect. So, evaluation should be based on source images. Susceptibility artifacts may be caused by metallic foreign bodies or gastric or duodenal gases, resulting in pseudo- obstruction. In contrast to ERCP / PTC, which allows real time visualization of the ducts, MRCP only allows static demonstration of biliary channels. So, presence of a communication between a cystic lesion and main pancreatic duct is difficult to ascertain. Respiratory motion artifact is another problem in Maximum Intensity Projection when a patient does not perform adequate breath holding. In such a case CBD and main pancreatic duct may appear disconnected, dilated and duplicated. Overestimation of ductal narrowing and pseudo stricture may result from nature of MIP reconstruction and from limited spatial resolution of MRCP. Lesions at periampullary region are difficult to diagnose as intramural part of common bile duct has little fluid. So, any calculus impacted at ampulla is difficult to diagnose. Also, contraction of choledochal sphincter may be misinterpreted as stone. So, in filling defects or stricture at ampulla repeat MRCP should be done [10].

MRCP has some other limitations as well. MRCP is less useful if performed after endoscopic or percutaneous procedures because air, clot, spasm of sphincter of Oddi or stent may artefactually influence the ductal appearance. MRCP cannot be performed in patients with metallic device in abdominal cavity, patients with pacemakers or cochlear implants or in claustrophobic patients. It is difficult to obtain a good study in patients who are unable to hold breath due to ill health or otherwise. As MRCP is a promising 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.

AIMS AND OBJECTIVES
We proposed this study with the following aims and objectives:
- To evaluate the role of MRCP as a non-invasive diagnostic tool in patients with suspected obstructive biliopathies.
- To compare and correlate the MRCP findings with those of other modalities.
- To correlate the MRCP findings with patient's clinical profile &
- To evaluate the role of conventional MR imaging as an adjunctive tool in formulation of diagnosis.

REVIEW OF LITERATURE
The imaging of pancreatico-biliary region can be divided arbitrarily into four periods-plain film eras from 1895-1924, contrast medium era from 1924-1960, era of expanding technologies such as percutaneous Transhepatic cholangiography, Ultrasonography and nuclear scintigraphy followed by era of interventional radiology. Subsequently, imaging of the liver and gall bladder was the subject of interest by the new imaging modalities early in their evolution viz. Computed Tomography (CT) in 1975 and Magnetic Resonance (MR) in 1981.

The efficacy of magnetic resonance cholangiopancreatography in the evaluation of malignant perihilar biliary obstructions was studied by Yeh *et al.*, the reference being endoscopic retrograde cholangiography [11]. The study group included hilar cholangiocarcinoma in 26 patients, icteric hepatocellular carcinoma in 4 patients, gall bladder carcinoma in 5 patients and metastases from other than hepatobiliary origin in 5 patients. Axial and coronal MR images and post Gadolinium DTPA axial MR images were added simultaneously to MRCP. The presence and extent of malignant biliary obstruction were determined with both magnetic resonance cholangiopancreatography and endoscopic retrograde cholangiography following the known criteria: an abrupt and irregular character of a distal narrow segment, a proportionally dilated biliary tree proximally, and an irregularly shaped intraluminal filling defect. The efficacy of the MRCP examination in detecting the presence of biliary obstruction, its anatomical extent, and the underlying cause, was compared to that of endoscopic retrograde cholangiography. Magnetic resonance cholangiopancreatography was successfully performed on all patients, whereas ERCP was unsuccessful in two patients. Both MRCP and ERCP were very effective in detecting the presence of biliary obstructions. MRCP was superior to ERCP in its investigation of anatomical extent and the cause of jaundice. Although MRCP was effective for evaluating the intraluminal component of biliary tumour, simultaneous MR imaging was required to determine the resectibility and the extent of resection if possible. In conclusion, the authors reported that specifically the performance of MRCP is promising for interpretation of cholangiocarcinoma and gall bladder carcinoma, but is relatively ineffective for icteric HCC and metastasis. They also concluded that magnetic resonance cholangiopancreatography performed simultaneously with MR represented an ideal noninvasive diagnostic tool to evaluate malignant perihilar biliary obstructions [11].

Kim *et al.*, in 2000 performed MR studies in 62 patients with mean age of 63 years who were subjected to conventional T1 and less heavily weighted T2 images as well as Gadolinium enhanced dynamic images and heavily T2 weighted images (35). Biliary

dilatation was diagnosed if > 7 mm diameter at less than 60 years of age, > 9 mm if more than 60 years of age and > 10 mm if patient is post cholecystectomy. Malignant obstruction was diagnosed if tumour was visualized, presence of double duct sign, abrupt termination of bile duct or irregularity of obstructed margin. The area under ROC (Receiver operating characteristic) was larger for MRCP with T2 and T1 than for MRCP alone. Mean diagnostic accuracy, sensitivity and specificity increased by 19 %, 17 % and 20% respectively. They concluded that use of non-enhanced T1 and less heavily weighted T2 images with MRCP images significantly improved diagnostic accuracy but addition of gadolinium enhanced dynamic images increased the level of confidence in only 17-24 % of cases [12]. Evaluation of iatrogenic bile duct injury by magnetic resonance cholangiopancreatography was studied by Khalid *et al.*, in 2000 [13]. They performed MRCP using breathhold T2 weighted half Fourier acquisition single shot spin echo fat suppressed sequence in ten postoperative patients suspected of having bile duct injury as a result of surgery. Excision injury was diagnosed if a segment of bile duct was not visible on any of the MRCP sequences. Positive cases were further classified according to the anatomical location and extent of injury. They compared the results with endoscopic retrograde cholangiography in 5 patients, percutaneous transhepatic cholangiography in one, surgery in four and clinical follow up in three. Three patients had normal findings on MRCP and remained asymptomatic on follow up. Four patients had duct excision injury on MRCP that was surgically proven, and one had stricture, which was confirmed by percutaneous transhepatic cholangiography. Two patients had findings suggestive of cystic duct leak which was confirmed on cholangiography. The authors concluded that MRCP could accurately characterize and diagnose excision injuries and postoperative strictures and anatomically classify these injuries for reparative surgeries [13].

Lopera *et al.*, studied the usefulness of MRC in defining the extent of biliary duct involvement in patients with malignant hilar and perihilar biliary obstruction and also evaluated if findings alone at MRC are sufficient to plan percutaneous interventions. High diagnostic accuracy of MRC in determining the extent of ductal involvement in patients with malignant hilar and perihilar obstruction allows adequate planning of percutaneous interventions in majority [14]. Pisani *et al.*, in 2001 conducted a study to compare the diagnostic concordance among ERCP and MRCP, analyzing sensitivity, specificity, positive predictive value, negative predictive value and accuracy [4]. There were 41 patients in the studied group, divided in two groups: I- without biliary or pancreatic tract obstruction, and II-with obstruction. Group II was further divided in A-obstruction due to lithiasis, and B- due to other causes. Concordance between the two methods was found in 67% in group I and 82% in group II. Sensitivity of ERCP was 94% and magnetic resonance cholangiopancreatography was 89%. Specificity of endoscopic retrograde cholangiopancreatography was 100% and MRCP was 67%. MRCP positive predictive value was 93%, the negative predictive value was 50% and the accuracy was 85%. Authors concluded that both methods showed the same sensitivity [4]. Laokpessi *et al.*, in 2001 studied the performance of magnetic resonance cholangiopancreatography in the preoperative diagnosis of choledocholithiasis [15]. In this study, 147 patients with clinical and biochemical signs of CBD stones underwent MRCP. ERCP was done in 101 patients with a past history of cholecystectomy and 46 patients underwent cholecystectomy along with intraoperative cholangiography. The extraction of stone was considered the gold standard in this study. The investigators found no significant statistical difference between MRC and other techniques and concluded that MRCP is comparable to ERCP but more specific than intraoperative cholangiography. However, its diagnostic utility remains limited in case of microlithiasis and cholangitis [15].

In a study by Taylor *et al.*, in 2002, accuracy of MRCP was prospectively assessed in a large number of patients with suspected pancreaticobiliary disease [16]. The study group included 146 patients who were referred for ERCP. MRCP findings were correlated with ERCP findings or when ERCP was unsuccessful, with repeat ERCP, percutaneous transhepatic cholangiography, or surgery. Diagnosis included 46 patients with choledocholithiasis and 12 with biliary stricture. The sensitivity, specificity, positive predictive value and negative predictive value for the diagnosis of choledocholithiasis by MRCP was 97.9 %, 89 %, 83.6 % and 98.6% respectively. All 12 strictures were diagnosed by MRCP with sensitivity 100 % and specificity 99.1 %. According to authors, MRCP is an accurate noninvasive alternative to ERCP for imaging the biliary tree, as choledocholithiasis and biliary strictures can be easily and reliably diagnosed or excluded by MRCP. Hence, MRCP should be increasingly used in patients with suspected biliary obstruction to select those patients who require a therapeutic procedure [16].

In a prospective study, Rosch *et al.*, compared the diagnostic accuracy of MRCP versus ERCP, CT and endoscopic ultrasonography in biliary strictures [7]. They included 50 patients suspected of having biliary strictures out of which 40 patients underwent all imaging tests. Reference standards for comparison were surgery, a biopsy confirming malignancy, or the clinical course during follow up. The sensitivity and specificity for the diagnosis of malignancy were 85 % and 75 % for ERCP / PTC, 85 % and 71 % for MRCP, 77 % and 63 % for CT, and 79 % and 62 % for EUS respectively. The combination of MRCP and EUS improved

specificity. The authors concluded that although MRCP provided the same diagnostic information as direct cholangiography, it has limited specificity for the diagnosis of malignant strictures. So, for the diagnosis of malignant strictures a battery of tests including ERCP are still required [7].

In a study by Irie *et al.*, in 2002, the role of MRCP in imaging of ampullary carcinoma was compared to endoscopic retrograde cholangiography [40]. The purpose of the study was to demonstrate the appearance of ampullary carcinoma on MR imaging. Dynamic study was done to assess the tumour resectibility and looked at signal intensity of the tumour and enhancement pattern. The study group included 16 patients out of whom dynamic study detected all tumours except one, and all detected tumours showed delayed enhancement. In authors' opinion, dynamic MR study is mandatory in diagnosing ampullary carcinoma, because it can depict most of the tumour and delayed enhancement of such tumours are characteristic. MRCP can also provide reliable information about pancreaticobiliary anatomy and can replace ERCP [17].

In a study by Schwartz *et al.*, in 2002, the role of MR imaging and MRCP in gall bladder carcinoma was evaluated [18]. They retrospectively correlated the findings with available surgical and biopsy information. They used T1 weighted spin-echo, T2 weighted fast spin -echo, single shot fast spin -echo and gadolinium enhanced gradient echo sequences in 34 patients with gall bladder carcinoma. The images were reviewed for the appearance of the primary neoplasm and for demonstration of hepatic, peritoneal, duodenal and nodal involvement. Sensitivity of MRCP for direct hepatic invasion was 100 % and was 92 % for nodal spread. In author's opinion, MRI and MRCP can provide relevant information for preoperative staging of gall bladder carcinoma [18].

Tripathi et al. in 2002 evaluated the role of MRCP in 150 adult patients of biliary or pancreatic disease, and compared with those at surgery or at ERCP. MRCP could accurately identify the level of biliary obstruction in 58 patients. Characterization of benign or malignant nature of stricture was possible in 30 of 32 patients when findings of both MR and MRCP were analyzed together. In conclusion, authors stated that MRCP has high specificity and sensitivity for the detection of biliary dilatation, stricture, calculi and anatomical variations [19].

Kim *et al.*, in their study in 2002 compared the efficacy of MRCP and ERCP for the diagnosis of intrahepatic stones. The sensitivity and specificity of MRCP for detecting of intrahepatic stones were 97 % and 93 % respectively whereas the figures for ERCP were 58 % and 97 %. They found no significant difference between ERCP and MRCP for the detection of stones in common duct or gall bladder. They concluded that MRCP is more effective diagnostic method for the detection of intrahepatic stones [20]. In a study by Calvo *et al.,* in 2002, the authors assessed the diagnostic efficacy of MRCP and whether its use may eliminate the use of diagnostic ERCP [21]. The study group included 116 patients with suspected pancreaticobiliary diseases. Choledocholithiasis was initially suspected in 61 patients and MRCP diagnosed choledocholithiasis with a sensitivity of 91 % and a global efficacy of 90%. The level of duct obstruction was well visualized in all patients. Suprastenotic dilatation also showed a good correlation with ERCP. Choledocholithiasis was found in 32 patients (65 %) and in 3 patients (33%) in the high and intermediate probability groups respectively. ERCP was performed for only a diagnostic purpose in 3 (6%) and 2 (22%) patients of the high and intermediate probability cases. In authors' opinion, MRCP plays an important role in patients with a low or intermediate risk of choledocholithiasis, contributing to the avoidance of a purely diagnostic ERCP [21]. Zhong *et al.*, in their study compared the validity of various imaging modalities e.g. USG, CT, ERCP, PTC and especially MRCP in extrahepatic bile duct carcinoma [22]. The results of these imaging modalities were compared with those of operative and histological findings. The diagnostic accuracy rates of site location were USG 81.7 %, CT 84.6%, ERCP 75%, PTC 88.9% and MRCP 95% respectively. The diagnostic accuracy rates for nature of obstruction were USG 73.3%, CT 82.7%, ERCP 75%, PTC 88.9% and MRCP 95% respectively. They concluded that MRCP is superior to rest of the modalities not only in demonstrating the site but also the nature of lesion [22].

Romagnuolo *et al.*, in 2003 conducted a meta-analysis to precisely estimate the overall sensitivity and specificity of MRCP in suspected biliary obstruction and to evaluate clinically important subgroups [23]. They performed MEDLINE search for studies on the subject in English or French done during the period of January 1987 to March 2003. They included 67 studies consisting of 4711 patients in their analysis. MRCP had a high overall pooled sensitivity (95%) and specificity (97%). They concluded that MRCP is a noninvasive imaging test with excellent overall sensitivity and specificity for demonstrating the level and presence of obstruction [23]. In a study by Weber *et al.*, in 2003, evaluation of MRCP for the diagnosis of primary sclerosing cholangitis (PSC) was done in correlation with ERCP in 55 patients [24]. They also compared the diagnostic accuracy of various T2 weighted sequences, using breathhold coronal and transverse HASTE, paracoronal RARE and thin sliced HASTE. Morphologic criteria for PSC were documented and correlated with ERCP, which served as gold standard. Qualitative analysis of image quality showed no significant difference between RARE, HASTE and thin sliced HASTE. They concluded that MRCP seems to be

a reliable noninvasive imaging method to diagnose and follow up patients with PSC [24].

In a study by Di Cisare *et al.*, in 2003, comparison of the diagnostic accuracy of magnetic resonance cholangiopancreatography and endoscopic retrograde cholangiography in the diagnosis of malignant stenosis of the distal common bile duct was done [51]. 21 patients with a clinical suspicion of malignancy of distal bile duct were subjected to MRCP followed by diagnostic and where possible therapeutic ERCP. Histological diagnosis provided the reference for all 21 patients. MRCP was able to correctly identify the presence and site of distal biliary stenosis in 21/21 (100%) patients. ERCP instead allowed diagnosis in 20 /21 patients. ERCP may have some limitations as regards identification of distal bile duct stenoses in cases of critical stenoses [25]. Kats *et al.*, in 2003 reported a study of 202 patients to evaluate MRCP as a replacement for diagnostic ERCP for the suspicion of common bile duct stones [26]. ERCP was performed in all cases where MRCP indicated presence of stone and in those patients with a persistent strong suspicion for CBD stones despite negative MRCP. In 25 patients MRCP suggested CBD stones, which were proven by ERCP in 24 patients. Despite a negative MRCP, 27 patients underwent ERCP none of which showed a calculus. In this group, MRCP resulted in 100 % sensitivity and 96% specificity in detecting CBD stones. The authors suggested that in case of CBD stone suspicion, MRCP should be the procedure of choice [26]. In a prospective study, 33 patients with jaundice due to bile duct strictures underwent ERCP and MRCP examinations [27]. Surgical and histopathological correlations, which were used as the gold standard, were available in all cases, since all included patients underwent laparotomy. Diagnostic image quality was 88% for ERCP and 76% for MRCP. Comparing ERCP and MRCP, complete presentation of the biliary tract was achieved in 94% for ERCP and in 82% for MRCP. Correct differentiation of malignant from benign lesions was 76% for ERCP and 58% for MRCP. The authors concluded there was adequate presentation of bile duct strictures in high imaging quality for both techniques [27].

Vaishali *et al.*, evaluated 30 patients with biliary obstruction with MRCP. MRCP findings were confirmed on surgical exploration or clinical follow-up. MRCP had a sensitivity of 94.44%, specificity of 81.81%, positive predictive value of 89.47 %, and negative predictive value of 90% for the detection of malignant causes. The overall diagnostic accuracy for detection of level and cause of obstruction was 96.3% and 89.65%, respectively. The authors concluded that the high diagnostic accuracy of MRCP in evaluating patients with obstructive jaundice indicates that it has the potential to become the diagnostic modality of choice in such patients [28].

A study was conducted to determine the utility of MRC in the preoperative evaluation of patients with gallstone pancreatitis [29]. Sixty-four patients identified with gallstone pancreatitis based on clinical presentation and imaging studies underwent MRC. Seventeen of the 64 patients (27%) with gallstone pancreatitis were found to have CBD stones confirmed by ERCP. MRC correctly predicted CBD stones in 16 of the 17 patients (sensitivity = 94%). MRC was able to visualize gallbladder stones in 57 of 62 patients (94%). The authors concluded that MRC is an effective, noninvasive screening tool for CBD stones, appropriately selecting candidates for preoperative ERCP and sparing others the need for an endoscopic procedure with its associated complications [29].

Shanmugam *et al.*, assessed the predictive value of MRCP in the diagnosis of biliary pathology. Clinical, laboratory and investigational data were evaluated from 351 patients undergoing MRCP at two hospital sites over a five-year period. MRCP findings were compared with ERCP or operative findings and appropriate clinical endpoints [36]. The predominant presentation was abdominal pain (n = 190). Features of pancreatitis were present in 59, cholangitis in 26 and jaundice in 109 patients. Ultrasound was the initial investigation in 312 (89%) (176 were gallstone positive). Common duct dilatation was evident in 114 patients and ductal calculi in 31. ERCP was successful in 212 of 283 (75%) patients. Significant ERCP - induced pancreatitis occurred in 12 (5.6%). Comparison between MRCP and ERCP was not possible in 85, due to failure of either technique. Nine patients underwent other investigations including intraoperative cholangiogram (IOC), percutaneous transhepatic cholangiogram (PTC) and were included. Of the 221 patients with full comparative data available, the MRCP showed a sensitivity of 97.98% and specificity of 84.4%. The authors stated that MRCP is highly sensitive and specific for choledocholithiasis and avoids the need for invasive imaging in most patients with suspected choledocholithiasis [30].

In a prospective randomized controlled trial, Hallal *et al.*, evaluated the effectiveness of MRCP in detecting choledocholithiasis in patients with mild resolving gallstone pancreatitis [31]. Patients group 1 (n = 34) underwent laparoscopic cholecystectomy (LC) and intraoperative cholangiography (IOC). Those randomized to group 2 (n = 29) had preoperative MRCP; of these, patients with negative MRCP underwent LC and IOC, patients with positive MRCP had preoperative ERCP followed by LC. The MRCP sensitivity was 100%, specificity 91%, positive predictive value 50%, negative predictive value 100 %, and accuracy 92%. The authors concluded that patients with resolving gallstone pancreatitis and a negative MRCP do not need preoperative ERCP or IOC. They stated that only patients with a positive MRCP will require preoperative ERCP [31].

Zhou *et al.*, conducted a study to evaluate the predictive value of magnetic resonance cholangiography (MRC) in selected patients before laparoscopic cholecystectomy (LC) [32]. Patients with risk factors for common bile duct (CBD) stones scheduled for elective LC underwent MRC followed by endoscopic retrograde cholangiography (ERC) to detect the stones and the accuracy of MRC. Selection of suspected patients was based on clinical, ultrasonographic, and laboratory criteria. During a 26-month period, a total of 267 patients were studied. Seventy-eight MRC identified patients were found to have CBD stones by ERC or laparoscopic cholangiography in the study. Seven of 78 patients were misdiagnosed as having CBD stones by MRC. In this study, MRC had a sensitivity of 100%, a specificity of 96.3%, a positive predictive value of 91.8%, and a negative predictive value of 100% for the detection of common bile duct stones. They concluded that with the use of LC, ERC is frequently performed before LC to detect CBD stones; but it is invasive with a well-documented complication rate. MRC is a simple non-invasive method for preoperative screening for CBD stones in at-risk patients. In this study if ERC had been limited to patients with a positive MRC, it would have reduced the need for ERC by 68.2%, and the complications of preoperative examination would be minimized significantly [32].

In year 2008, Takashi Tajiri *et al.*, determine the MRCP as the radiologic technique of choice for assessing the extent of disease. The limitations of conventional imaging techniques have led to the increased use of MRCP, which is a noninvasive and highly accurate technique for the evaluation of patients with biliary obstruction. MRCP is optimally suited for the visualization of both intrahepatic and extrahepatic cholangiocarcinomas, which appear as hypointense lesions on T1-weighted images and hyperintense lesions on T2-weighted images. Images can be enhanced with the use of superparamagnetic iron or by delayed gadolinium enhancement. The overall diagnostic accuracy for assessment of the level and cause of obstruction was 96.3% and 89.7%, respectively [33].

In year 2009, Aoto, MD *et al.*, determine the usefulness of MRCP in the evaluation of pregnant patients with acute pancreaticobiliary disease and its additional value over ultrasound. MRI studies of pregnant patients who were referred because of acute pancreatico-biliary disease were included. MR images and patient charts were reviewed retrospectively to determine clinical outcome and the results of other imaging studies. 18 pregnant patients underwent MRCP because of right upper quadrant pain, pancreatitis, cholangitis or jaundice. 15 patients were also evaluated with ultrasound. Biliary dilatation was detected in eight patients by ultrasound, but the cause of biliary dilatation could not be determined by ultrasound in seven patients. MRCP demonstrated the etiology in four of these

patients choledocholithiasis, Mirizzi syndrome, choledochal cyst and intrahepatic biliary stones and excluded obstructive pathology in the other four patients. MRCP was unremarkable in the seven patients who had no biliary dilatation on ultrasound. Three patients underwent only MRCP; two had choledocholithiasis and one cholelithiasis and pancreatitis. Choledocholithiasis diagnosed with MRCP was confirmed by ERCP. Mirizzi syndrome and a choledochal cyst were confirmed by surgery. The patients with normal MRCP and one patient with intrahepatic stones improved with medical treatment. MRCP appears to be a valuable and safe technique for the evaluation of pregnant patients with acute pancreaticobiliary disease. Especially when ultrasound shows biliary dilatation, MRCP can determine the etiology and save the patient from unnecessary ERCP by excluding a biliary pathology [34]. In year 2010, F. Maccioni *et al.*, determine the overall accuracy of MRCP in the evaluation of bile duct stones is extremely high, with sensitivity and specificity values ranging from 96 to 100%The sensitivity of MR cholangiography for the detection of bile ducts strictures is approximately 95%The failure rate of endoscopic retrograde cholangiopancreatography in these patients varies between 10% and 48%, as compared with 3%-5% in patients with normal anatomy. MR cholangiography clearly depicts the site of the biliaryenteric anastomosis and demonstrates the status of the intrahepatic ducts [35].

There is absence of consensus about which sequence is more appropriate for demonstrating the cause of obstruction. The lack of outcome studies indicates that the technique of magnetic resonance cholangiopancreatography is still evolving. The refinement of MR cholangiographic sequences, including the use of a phased array coil and breathhold technique, has led to the production of high-quality images with the capability to detect even small calculi. The sensitivity and specificity in diagnosing the level and cause of obstruction has markedly improved in recent years but is still limited in diagnosing calculi less than 3 mm, lesions at ampulla and characterization of strictures.

MATERIAL AND METHODS
Sampling
Patients who present with jaundice, abdominal pain/swelling (typically in right upper quadrant), dark colored urine, diarrhea, itchy skin, easy bleeding or bruising, loss of appetite, malaise, pale stool & weight loss.

Exclusion Criteria
- Uncooperative patients
- Patients with claustrophobia
- Patients with pacemaker / cochlear implants in situ

Patient Preparation: Children and patients who were in altered sensorium required sedation

DATA COLLECTION AND ASSESSMENT: Clinical data was collected prospectively

Tools

MRI - PHILIPS, Intera 1.5 tesla.
CT - GE, Optima CT 660 - 64 slice.
USG - GE, Volvusion E8.

Statistical Tools

The information collected regarding all the selected cases were recorded in a Master Chart. Data analysis was done with the help of computer using Epidemiological Information Package (EPI 2010) developed by Centre for Disease Control, Atlanta. Using this software range, percentages, means, correlation coefficient, chi square were calculated. Kruskul Wallis chi-square test was used to test the significance of difference between quantitative variables and Yate's chi square test for qualitative variables. if the correlation coefficient is more than 0.5, then there exist cause and effect relationship between those two variables.

IMAGES
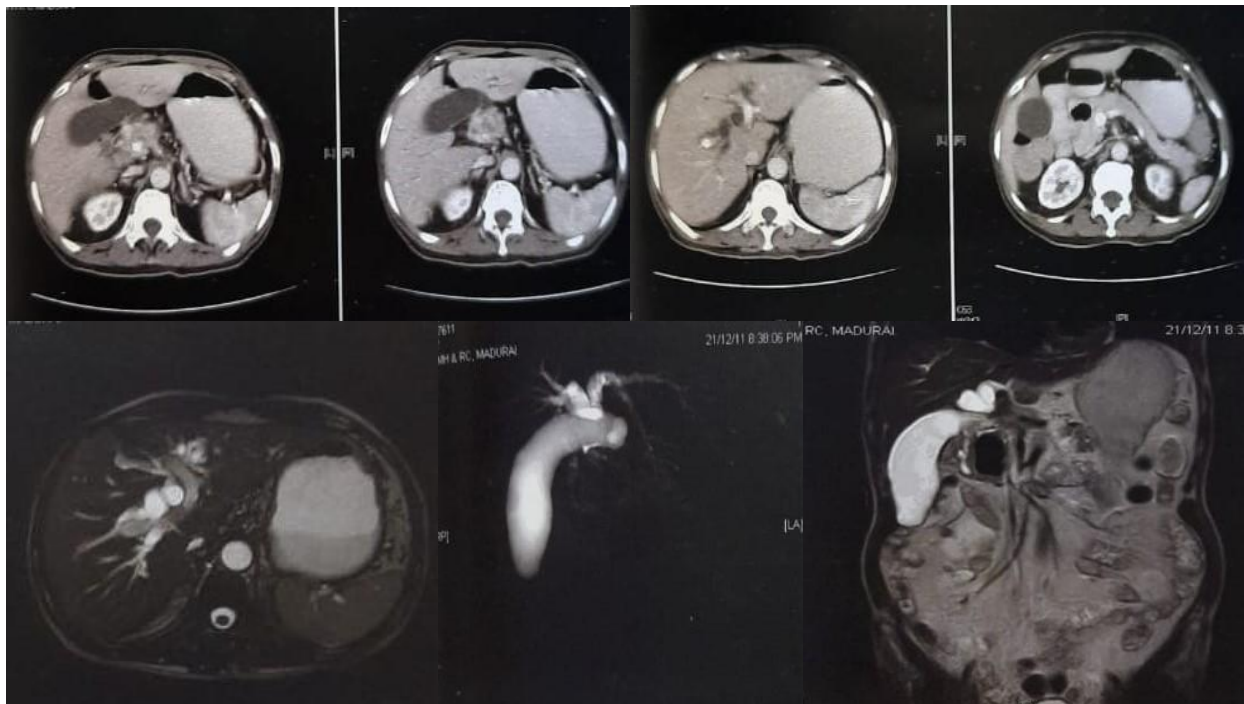
Case 1- CECT axial images showing IHBRD and distended GB due to proximal CBD obsttuction- cholagiocarcinoma. (Left) esshMRCPrad, BTFE axial and (right)T2W TSE coronal images showing dilatation of RHD and LHD, distended GB in a case of proximal CBD cholangiocarcinoma
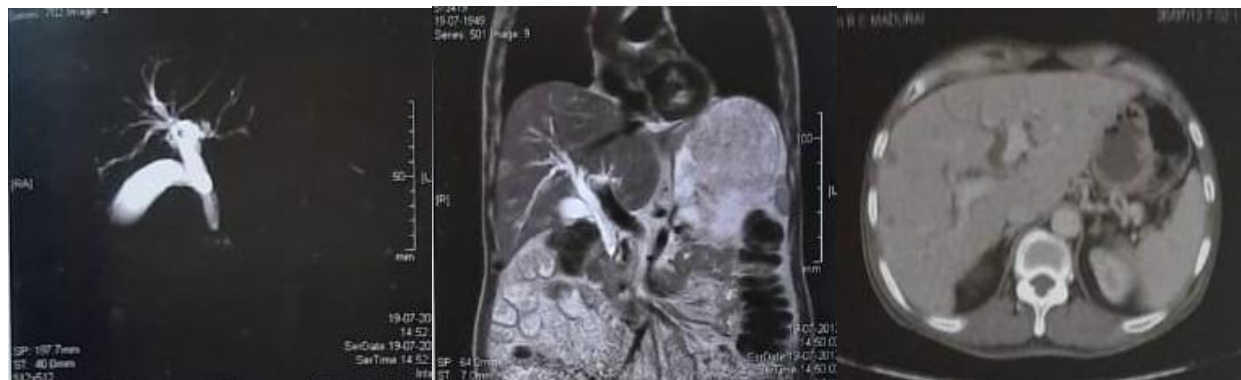
Case 2- (Left) esshMRCPrad and (right) T2W TSE coronal images showing dilated proximal CBD due to periampullary growth obstructing mid and distal CBD.T2 W-TSE image also showing multiple liver mets
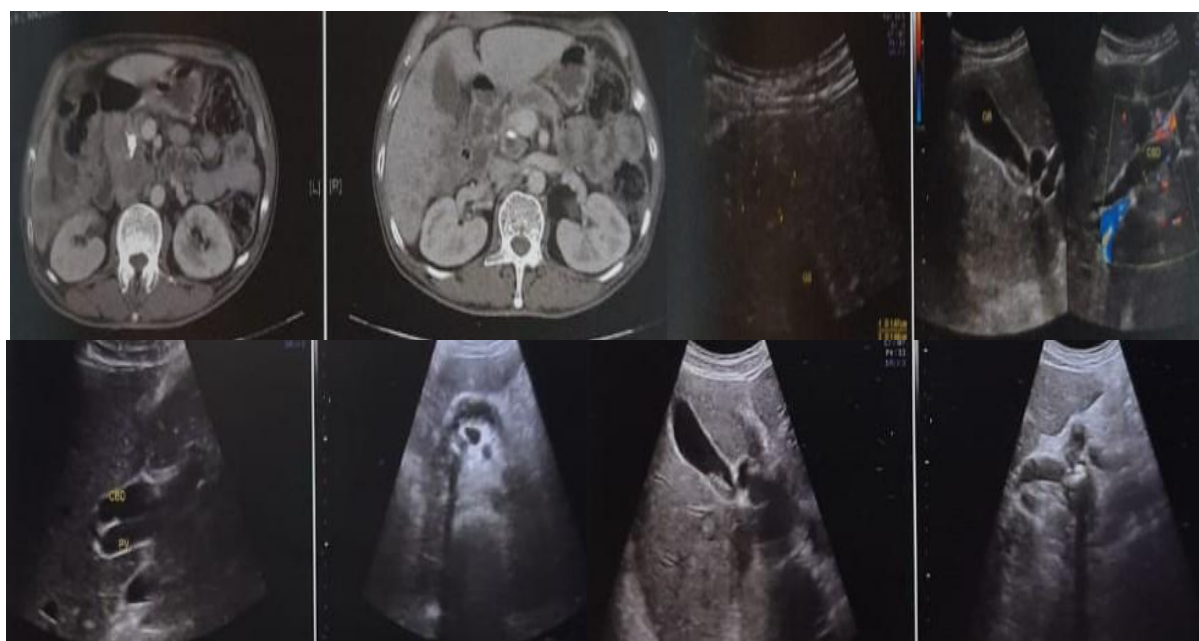
Case 2- CECT axial images showing IHBRD and multiple hypodense liver and nodal deposits(mets). USG shwosing hypoechoic liver mets and tiny GB calculus and sludge and dilated CBD

Case 5 - (Left) esshMRCPrad, MIP and (right) T2W TSE coronal images showing grossly dilated CBD IHBR and MPD in a case of pancreatic head mass

Case 6 - USG showing hypoechoic liver mets. CECT axial images after CBD stenting (stent insitu) and hyperdense liver mets
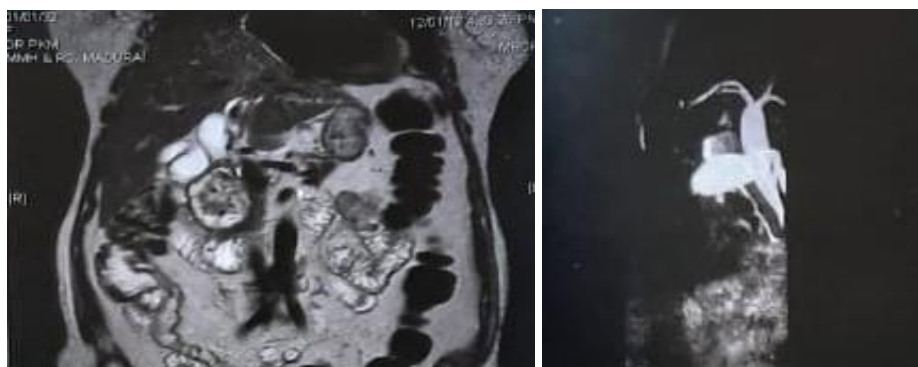
Case 7 (Left) esshMRCPrad, MIP and (right) T2W TSE coronal images showing fusiform dilatation of CBD with gradula tapering in diatal end, right and left hepatic duct not dilated-type 1 choledochal cyst

Case 12 - (Left) T2W TSE coronal, MIP and esshMRCPrad (right) images showing dilated right and left hepatic duct due to hilar cholagiocarcinoma with moderately distended GB
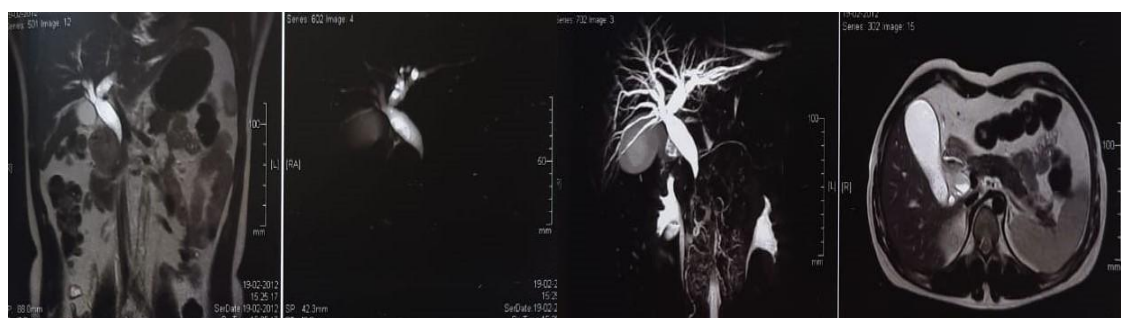
Case 17 - (Left) T2W TSE coronal, MRCP 3D (central two images) and BTFE axial shwosing dilated CBD with abrupt termination in a case of PAC with dilatd right and left hepatic duct. MPD is not dilated

Case 25 - MRCP-3D images showing dilated CBD with gradual tapering at the distal end with over distended GB filled with calculi- in a case of BBS

Case 26 - (left) MRCP and (right) T2W TSE coronal images showing dilated CBD with abrupt termination in mid part in a case of carcinoma pancreas
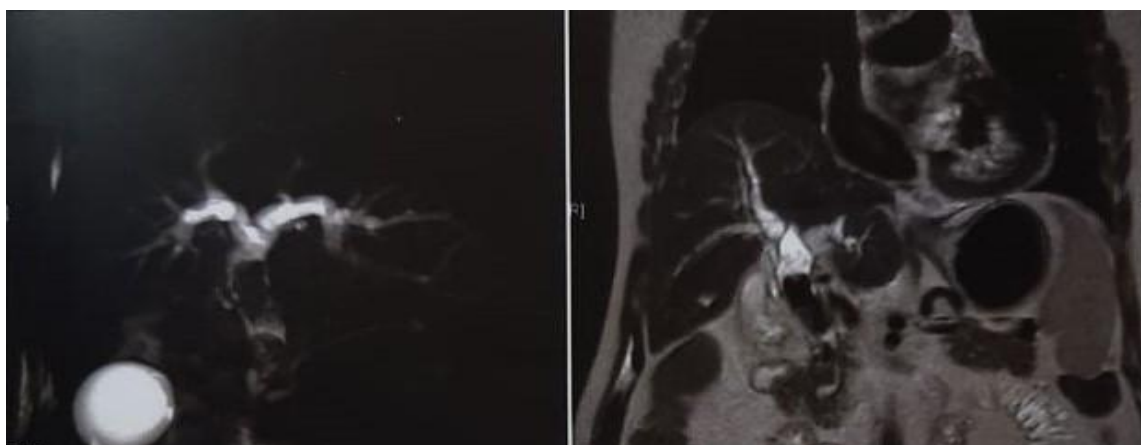
Case 27 - (left) MRCP and (right) T2W TSE coronal images showing large calculus in mid CBD lumen, causing dilatation of IHBR and proximal CBD

Case 32 - (left) MRCP -MIP and (right) T2W TSE coronal images showing dilated hepatic duct (Left > Right) and distended GB in a case of hilar cholangiocarcinoma

Case 39 - USG images showing echogenic lesion in mid CDB. Dilated CBD and IHBR
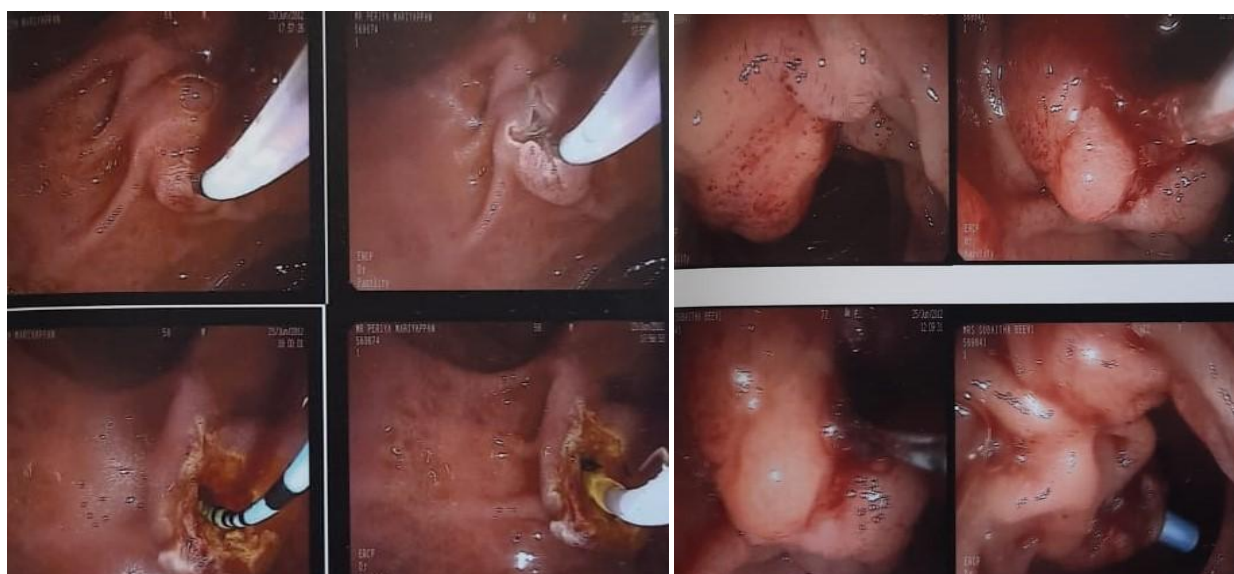
Case 41- (Left) ERCP intraprocedural photograph showing inflamed papilla and papillotomy CBD calculus. Case 38 (right) showing large periampullary growth
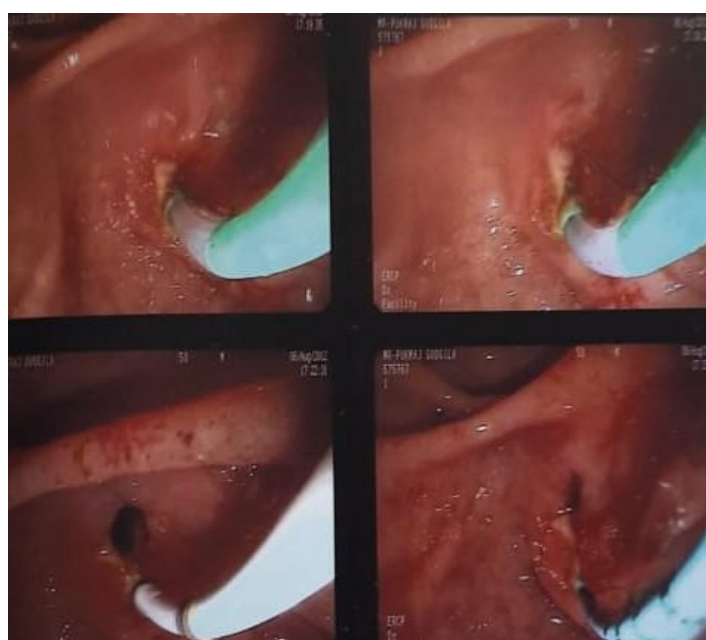
Case 49 ERCP intraprocedural photograph showing papillotomy in a case of benign biliary stricture

Case-46 - (left) MRCP- 3D and (right) T2W TSE coronal images showing dilated CBD with gradual tapering at distal end with multiple GB calculi – BBS

Case 48 - (left) MRCP- 3D and (right) T2W TSE coronal images showing fusiform dilatation of CBD with normal RHD and LHD in a case of Type 1 choledochal cyst
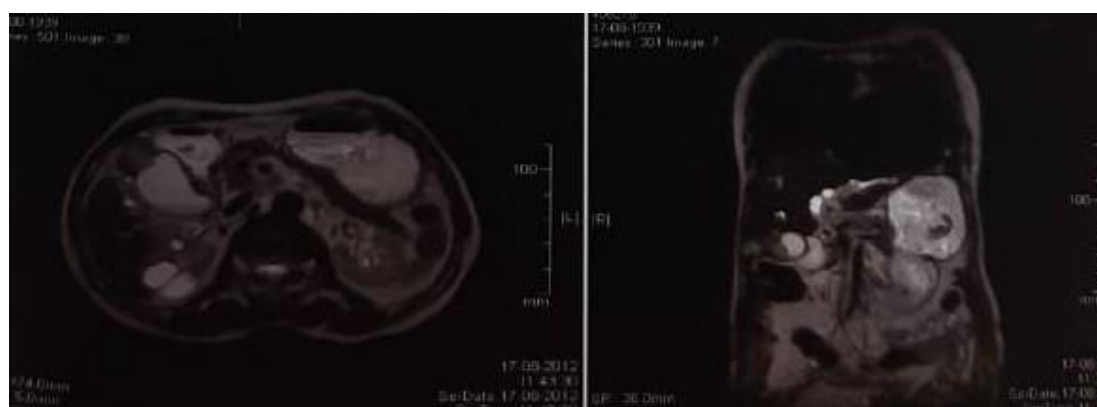
Case 52- T2W TSE axial and coronal images showing polypoidal mass lesion involving the GB, obstructing the proximal CBD. Multiple lymph nodes at the porta hepatis

OBSERVATION AND RESULTS

This prospective study was conducted on sixty patients with clinically suspected biliary obstruction. The cause of biliary obstruction was finally identified on the basis of direct cholangiography/ surgery / histopathology as Benign Biliary Stricture in 14 patients, choledocholithiasis in 7 patients, Choledochal Cysts in 3 patients, ulcerated periampullary growth in 1 patient, Portal Biliopathy in 2 patients, external compression in 2 patients, hepatitis 3 patients Cholangiocarcinoma in 10 patients, Carcinoma of the Gall Bladder in 3 patients and Periampullary carcinoma in 15 patients. All these patients underwent Magnetic Resonance Cholangiopancreatography (MRCP).

The results of MRCP were compared with ERCP in 21 patients and with operative and histopathological findings in rest of the patients. Therapeutic ERCP was done in 9 patients (i.e.-ERCP Vedio snapshot case 38 & 58, CECT case 7 & 23).

OBSERVATION

Table-1: Age and sex distribution.

AGE GROUP (years)	Male	Female
00-10	0	1
11-20	3	0
21-30	3	2
31-40	4	3
41-50	7	5
51-60	9	2
61-70	5	1
71-80	8	5
81-90	2	0
Total	41	19

There were 41 male and 30 females with age range of 10 year to 85 years, maximum number of patients belonged to 71 to 80 years (13, 21.6%) followed by 41 to 50 years (12, 20%).

Clinical Presentation

Patients with obstructive jaundice presented with a variety of symptology as described in Table-2.

Table-2: Clinical features

Clinical features	No. of patients	Percentage
Jaundice	51	85.0
Pain in right hypochondrium	43	71.6
Pruritis	12	20.0
Fever	12	20.0
Loss of appetite	14	23.3
Loss of weight	10	16.6
Acholic stool	11	18.3
Nausea	21	35.0
Constipation	06	10.0
Dysphagia	03	05.0
Bleeding per rectum	01	01.6
Giddiness	01	01.6
Pedal edema	02	03.3
Hematemesis	01	01.6

Jaundice was the most common presentation (85%), followed by pain abdomen especially right hypochondrium (71.6%), nausea (35%), loss of appetite (23.3%) pruritus (20%), fever (20%).

MRCP FINDINGS
MRCP findings are summarized in Table 3-6.

Table-3: MRCP Findings (n=60)

PoNo	IHBRD	CONFLUENCE	DILATED CBD	LEVEL OF BLOCK
1	+	+	-	P
2	+	+	+	M
3	+	+	+	D
4	+	-	-	Hilar
5	+	+	+	D
6	+	+	+	D
7	+	+	+	D
8	+	+	+	D
9	+	+	+	D
10	+	+	+	M
11	+	+	+	D
12	-	-	-	Hilar
13	-	-	-	N
14	+	+	+	D
15	+	+	+	D
16	+	+	+	D
17	+	+	+	D
18	+	+	+	D
19	+	-	-	Hilar
20	+	-	-	Hilar
21	+	+	+	M
22	+	+	+	D
23	+	+	+	D
24	+	+	+	D
25	+	+	+	D
26	+	+	+	M
27	+	+	+	M
28	+	+	-	P
29	+	+	+	D
30	+	+	-	P
31	+	+	+	M
32	+	+	-	Hilar
33	+	+	+	D

34	+	+	+	D
35	+	-	-	Hilar
36	+	+	+	D
37	+	-	-	Hilar
38	+	+	+	D
39	+	+	+	M
40	+	+	+	M
41	+	+	+	D
42	+	+	+	M
43	+	+	+	N
44	+	+	+	D
45	+	-	-	N
46	+	+	+	D
47	+	-	-	N
48	+	+	+	D
49	+	+	+	D
50	+	+	+	D
51	+	+	+	D
52	+	+	-	P
53	+	+	-	D
54	+	+	+	D
55	+	-	-	Hilar
56	+	+	+	D
57	+	+	+	D
58	+	+	+	M
59	+	-	-	Hilar
60	+	+	+	D

KEY: S. No.-serial number, IHBRD- intrahepatic biliary radicle dilatation, CBD- common bile duct, P- proximal third of CBD, M- middle third of CBD, D-distal third of CBD, H- hilum, ND –no diagnosed.

IHBRD was present in 58 patients (96.6%). Confluence was patent in 50 patients (83.3 %).

CBD was dilated in 45 patients (75%). No obstruction was found in 2 patients (3.3%).

Hilar block was diagnosed in 10 patients (16.7%). Block was at the proximal third of CBD in 3 patients (5%), at mid third in 10 patients (16.7%), and at distal third of CBD in 33 patients (55 %).

Table-4: Diagnosis Suggested at MRCP

Diagnosis	Cases	
	No	%
Benign	28	46.7
Benign biliary structure	13	21.7
Choledocholithiasis	7	11.7
Choledochal cyst	3	5
Ulcerated periampullary growth	Nil	Nil
Portal biliopathy	2	3.3
External compression	2	3.3
Hepatitis	1	1.7
Malignant	28	46.7
Cholangiocarcinoma	10	16.7
Carcinoma gall bladder	3	5
Periampullary carcinoma	15	25
No obstruction	4	6.7
Total	60	100

CBD calculus was diagnosed in 9 patients, of which it was identified as the cause of obstruction in 7 patients. Stricture was diagnosed as the cause of obstruction in 48 patients, of which 28 were diagnosed as malignant and 20 were diagnosed as benign strictures. No cause of obstruction was found in 4 patients and 1 patient was diagnosed Periampullary carcinoma was confirmed by biopsy as ulcerated periampullary growth in patient of gastro esophageal reflux disease.

Table-5: Benign causes of block at MRCP

S. N	Site of block	Cause	Calculus in CBD (No. /size)	Gall bladder	CBD Diameter
1	D	Ulcerated periampullary growth	-	Distended	23 mm
2	D	CDC	-	Distended	16 mm
3	D	BBS	-	Normal	9 mm
4	D	BBS	-	Normal	8 mm
5	M	External compression	-	Normal	12 mm
6	N	-	-	Cholelithiasis	6 mm
7	D	BBS	-	Cholelithiasis	10 mm
8	M	BBS-PB	-	Normal	12 mm
9	D	BBS	-	Cholelithiasis	7 mm
10	D	BBS	-	Overdistended	11 mm
11	D	BBS	-	Cholelithiasis	10 mm
12	M	C	3.2 cm	Distended	29 mm
13	P	External compression	-	Nodal mass at porta	9 mm
14	Intrahepatic	Hepatitis	-	GB wall edema	7 mm
15	D	C	8 mm	Thick wall +sludge	11 mm
16	P	BBS	-	Normal	6 mm
17	D	C	8 mm	Surgically absent	16 mm -
18	M	C	1.4 X 1.0 cm	Cholelithiasis	12 mm
19	D	C	Multiple ~ 3 mm	Normal	13 mm
20	M	C	Multiple tiny~ 2-3 mm	Cholelithiasis	13 mm
21	D	BBS	-	Distended+sludge	10 mm
22	N	BBS	-	Overdistended, sludge and pericholecystic collection	6.2 mm
23	D	BBS	-	Cholelithiasis	12 mm
24	N	Acute viral hepatitis	-	Contracted	6 mm
25	D	CDC	-	Normal	16.1 mm
26	D	BBS	-	Normal	8.4 mm
27	D	BBS	-	Moderately distended	10.7 mm
28	D	BBS	-	Normal	9.6 mm
29	D	BBS		Distended	7.7 mm
30	D	BBS-PB	2 mm	Distended + sludge	7 to 13 mm
31	M	C	8.8 mm & 8.5 mm	Moderately distended	10 mm
32	D	CDC	2.5 x 1.5 cm	Moderately distended	30 mm

KEY: S. No.-serial number, N-not identified, CBD- Common bile duct, C- Calculus, BBS-Benign biliary stricture, PB-portal biliopathy, CDC-choledochal cyst

Out of 32 patients, CBD calculus was noted in 9 patients (28.1 %) out which 7 was identified as cause of obstruction (i.e. -case 58 & 60), benign biliary stricture in 12 patients (37.5%) (i.e. -case 50, 51 & 54), benign stricture due to portal biliopathy in 2 patient (6.25%) (i.e. -case 57), external compression in 2 patients (6.25%), Intrahepatitis cholestatis in 1 patient (3.1%) and Cholelithiasis was diagnosed in 7 patients (21.8%) (i.e. case 13, 20 &25).

Table-6: Malignant causes of block at MRCP

S. No	Site of block	Cause	Calculus /mass in CBD	Gall bladder	Additional	CBD Diameter
1	P	CC	-	Distended	Periampullary diverticulum	17 mm
2	M & D	PAC	-	Multiple calculi + sludge	Multiple nodal and liver deposits	10 mm
3	Hilar	Ca.GB	-	Polypoidal mass in fundus	Liver mets	15 mm
4	D	PAC	-	Normal	Multiple liver mets and dilated MPD	24 mm
5	D	PAC	Sludge	Distended	Multiple liver mets and dilated MPD	14 mm
6	D	PAC	-	Distended	Enlarged periportal lymph nodes.	13 mm
7	Hilar	CC	-	Moderately distended	-	6 mm
8	D	PAC	Mass	Contracted	MPD dilated and beaded appearance.	16 mm
9	D	PAC	-	Calculus 13 mm	Partial thrombosis of portal vein, left inguinal hernia, gross ascites, extensive omental thickening	14 mm
10	D	PAC	-	Distended	Peripancreatic lymph node, liver mets	19 mm
11	D	PAC		Distended	MPD dilated	25 mm
12	Hilar	CC	-	Distended	-	12.4 mm
13	Hilar	CC	-	Sludge + calculus 10 mm	Multiple liver mets, multiple lymph nodes at porta and peripancreatic region.	14 mm
14	D	PAC	-	Overdistended	Chronic calcific pancreatitis and head mass, grossly dilated MPD, Chronic portal vein thrombosis and portal cavernoma transformation	11 mm
15	M	CC	-	Normal	Ca. Pancreas with liver mets, Hepatomegaly	10 mm
16	D	PAC	-	Distended	-	12 mm
17	M	CC	Mass	Distended, multiple calculi, minimal wall thickening and wall thickening-calculus cholecystitis	-	14 mm
18	Hilar	Hilar CC	Mass	Normal	-	9 mm
19	D	PAC	-	Distended	Invasive squamous cell carcinoma of distal esophagus, multiple enlarged paraaortic, peripancreatic and celiac lymph nodes.	16.4 mm
20	Hilar	Hilar CC	-	Normal -	Multiple enlarged lymph nodes in porta hepatis, paraaortic and paracaval	Collapsed
21	D	PAC		Distended + sludge	-	25.9 mm
22	D	N	-	Distended + sludge	-	8.2 mm
23	P	Ca GB	-	Mass	Multiple enlarged lymph nodes in porta hepatis, paraaortic, celiac axis and peripancreatic.	Collapsed
24		Ca GB	-	Mass	-	15 mm
25	Hilar	Hilar CC	Mass	Infiltrated	Gross ascites	Collapsed
29	D	PAC	-	Distended	-	30 mm
28	Hilar	Hilar CC	Mass	Infiltration	-	4 mm

KEY: S. No.-serial number, N-not identified, CC-Cholangiocarcinoma, Ca GB-Carcinoma gall bladder, PAC- Periampullary carcinoma.

Out of the 28 patients, Periampullary Carcinoma was identified as the cause in 15 patients (53.5%) (i.e. -case 16 &17), Carcinoma Gall Bladder in 3 patients (10.7 %) (i.e. -case 52) and Cholangiocarcinoma in 10 patients (35.7 %)(i.e. -case 12 & 32). Cholelithiasis was identified in 4 patients. Liver metastasis was diagnosed in 7 patients (i.e. -case 2). Retroperitoneal or periportal lymphadenopathy was diagnosed in 7 patients.

FINAL DIAGNOSIS
Surgery/Histopathology

Table-7: Final Diagnosis (n=60)

Diagnosis	Cases	
	No	%
Benign	32	53.3
Benign biliary stricture	14	23.3
Choledocholithiasis	7	11.7
Choledochal cyst	3	5
Ulcerated periampullary growth	1	1.7
Portal biliopathy	2	3.3
External compression	2	3.3
Hepatitis (Intrahepatic cholestasis)	3	5.0
Malignant	28	46.7
Cholangiocarcinoma	10	16.7
Carcinoma gall bladder	3	5.0
Periampullary carcinoma	15	25
Total	60	100

Comparison of MRCP findings and final diagnosis

Table 8: Agreement in the level and cause of block

S. N	Level of obstruction	Agreement at MRCP	Cause of obstruction	Agreement at MRCP
Benign				
1	D	+	Ulcerated periampullary growth	-
2	D	+	CDC	+
3	D	+	BBS	+
4	D	+	BBS	+
5	M	+	External compression	+
6	Intrahepatic	-	Intrahepatic cholestasis	-
7	D	+	BBS	+
8	M	+	BBS-PB	+
9	D	+	BBS	+
10	D	+	BBS	+
11	D	+	BBS	+
12	M	+	C	+
13	P	+	External compression	+
14	Intrahepatic	+	Hepatitis	-
15	D	+	C	+
16	P	+	BBS	+
17	D	+	C	+
18	M	+	C	+
19	D	+	C	+
20	M	+	C	+
21	D	+	BBS	+
22	N	-	BBS	-
23	D	+	BBS	+
24	Intrahepatic	-	Acute viral hepatitis	+
25	D	+	CDC	+
26	D	+	BBS	+
27	D	+	BBS	+
28	D	+	BBS	+
29	D	+	BBS	+
30	D	+	BBS-PB	+
31	D	+	C	+
32	D	+	CDC	+

S. N	Level of obstruction	Agreement at MRCP	Cause of obstruction	Agreement at MRCP
Malignant				
1	P		CC	
2	M & D	+	PAC	+
3	Hilar	+	CaGB	+
4	D	+	PAC	+
5	D	+	PAC	+
6	D	+	PAC	+
7	Hilar	+	CC	+
8	D	+	PAC	+
9	D	+	PAC	+
10	D	+	PAC	+
11	D	+	PAC	+
12	Hilar	+	CC	+
13	Hilar	+	CC	+
14	D	+	PAC	+
15	M	+	PAC	+
16	D	+	PAC	+
17	M	+	CC	+
18	Hilar	+	Hilar CC	+
19	D	+	PAC	+
20	Hilar	+	CC	+
21	D	+	PAC	+
22	M	+	CC	+
23	D	+	PAC	+
24	P	+	Ca GB	-
25	D	+	Ca GB	+
26	Hilar	+	CC	+
27	D	+	PAC	+
28	Hilar	+	Hilar CC	+

KEY: +-agreement ,--disagreement, S. No.- serial number, P- proximal third of CBD, M- middle third of CBD, D- distal third of CBD, H-Hilum, CC- Cholangiocarcinoma , Ca GB- Carcinoma gall bladder , PAC- Periampullary carcinoma, BBS-Benign biliary stricture, PB-portal biliopathy, CDC-choledochal cyst

In 57 of the 60 patients, MRCP agreed with final diagnosis in identifying the level of block (95%). MRCP agreed with final diagnosis in identifying the cause of obstruction in 55 of the 60 patients (91.6 %).

Level of block: The comparison between MRCP findings and final diagnosis considering the level of obstruction

Agreement of Results of MRCP with Final Diagnosis

Table-9: Level of Block

LEVEL OF BLOCK	NO. OF CASES
Agreement	57
Disagreement	3
Total	60
BENIGN	
Agreement	29
Disagreement	3
Total	32
MALIGNANT	
Agreement	28
Disagreement	0
Total	28

Comparison of Results of MRCP with Final Diagnosis

MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY	Final Diagnosis		Total
	Positive	Negative	
Positive	57	1	58
Negative	0	2	2
Total	57	3	60

Sensitivity of MRCP in identifying the level of obstruction in comparison with final diagnosis was found to be 100 %. Diagnostic accuracy of MRCP in identifying the level of obstruction in comparison with final diagnosis was found to be 98.3%.

Table-10: Correlation between MRCP and Final Diagnosis in Level of Block

	FINAL DIAGNOSIS	MRCP
Normal	0	3
Hilar	10	10
Proximal CBD	3	3
Mid CBD	10	10
Distal CBD	34	33
Intrahepatic	3	1
Total	60	60

KEY: CBD- Common Bile Duct

Pearson's correlation coefficient =0.9335

Agreement of Results of MRCP with Final Diagnosis

Table-11: Cause of Block

CAUSE OF BLOCK	NO. OF CASES
Agreement	55
Disagreement	5
Total	60
BENIGN	
Agreement	28
Disagreement	4
Total	32
MALIGNANT	
Agreement	27
Disagreement	1
Total	28

Comparison of Results of MRCP with Final Diagnosis

Magnetic Resonance Cholangiopancreatography	Final Diagnosis		Total
	Positive	Negative	
Positive	55	0	55
Negative	3	2	5
Total	58	2	60

Sensitivity of MRCP in identifying the cause of obstruction in comparison with final diagnosis was found to be 94.8 %. Diagnostic accuracy of MRCP in identifying the cause of obstruction in comparison with final diagnosis was found to be 95%.

Table 12: Correlation between MRCP and Final Diagnosis in Cause of Block

	FINAL DIAGNOSIS	MRCP
Not identified	0	4
Benign Biliary Stricture	14	13
Choledocholithiasis	7	7
Choledochal cyst	3	3
Ulcerated periampullary growth	1	0
Portal biliopathy	2	2
External compression	2	2
Hepatitis	3	1
Cholangiocarcinoma	10	10
Carcinoma gall bladder	3	3
Periampullary carcinoma	15	15
Total	60	60

Pearson's correlation coefficient =0.8855

COMPARISON OF USG FINDINGS WITH FINAL DIAGNOSIS
The comparison between Ultrasonographic findings with final diagnosis regarding the cause and level of obstruction.

Table-13: Correlation between USG findings and final diagnosis in level of block

	Final Diagnosis	USG
Normal	0	1
Hilar	10	10
Proximal CBD	3	3
Mid CBD	10	9
Distal CBD	34	29
Intrahepatic	3	1
Not identified	0	8
Total	60	60

Pearson's correlation coefficient =0.7851

Table-14: Correlation between USG and Final Diagnosis in Determining cause of block

	Final Diagnosis	USG
BBS	14	10
Choledocholithiasis	7	7
Choledochal cyst	3	3
Ulcerated periampullary growth	1	0
Portal biliopathy	2	2
External compression	2	1
Hepatitis	3	2
Cholangiocarcinoma	10	10
Ca GB	3	3
PAC	15	8
Not identified	0	14
Total	60	60

Pearson's correlation coefficient =0.5215

COMPARISON OF CECT FINDINGS WITH FINAL DIAGNOSIS
The comparison between contrast enhanced computed tomography findings with final diagnosis regarding the cause and level of obstruction

Table-15: Correlation between CECT findings & final diagnosis in level of block

	Final Diagnosis	CECT
Intrahepatic	3	0
Hilar	10	10
Proximal CBD	3	3
Mid CBD	10	10
Distal CBD	33	31
Not identified	0	5
Total	59	59

Pearson's correlation coefficient =0.8466

Table-16: Correlation between CECT and Final Diagnosis in determining Cause of Block

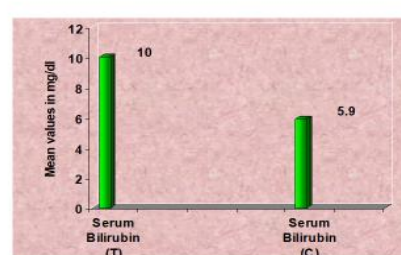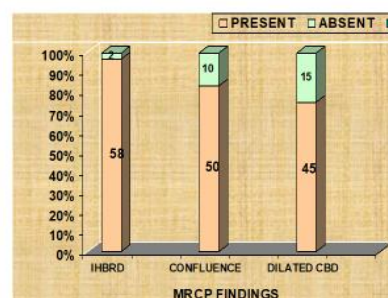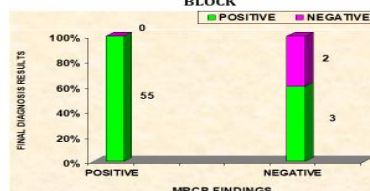|	FINAL DIAGNOSIS	CECT
BBS	14	11
Choledocholithiasis	7	7
Choledochal cyst	2	2
Ulcerated periampullary growth	1	0
Portal biliopathy	2	2
External compression	2	2
Hepatitis	3	0
Cholangiocarcinoma	10	10
Ca GB	3	3
PAC	15	16
Not identified	0	6
Total	59	59

Pearson's correlation coefficient =0.8885

Table-17: Identification of choledocholithiasis

Magnetic Resonance Cholangiopancreatography	Final Diagnosis		Total
	Positive	**Negative**	
Positive	7	2	9
Negative	0	51	51
Total	7	53	60

Sensitivity of MRCP in identifying choledocholithiasis was found to be 100%. Diagnostic accuracy of MRCP in identifying choledocholithiasis was found to be 95%. Specificity of MRCP in identifying choledocholithiasis was found to be 95%.

Positive predictive value of MRCP in identifying choledocholithiasis was found to be 77.8%. Negative predictive value of MRCP in identifying choledocholithiasis was found to be 100%.
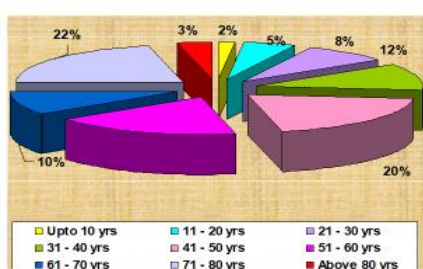
AGE DISTRIBUTION
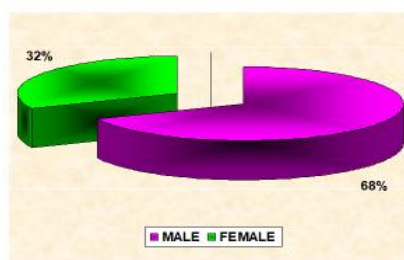
HAEMATOLOGICAL PARAMETERS

SEX DISTRIBUTION

MRCP FINDINGS

RELATIONSHIP BETWEEN MRCP FINDINGS AND FINAL DIAGNOSIS REGARDING LEVEL OF BLOCK

RELATIONSHIP BETWEEN USG FINDINGS AND FINAL DIAGNOSIS REGARDING LEVEL OF BLOCK
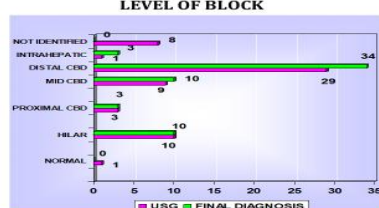
LEVEL OF BLOCK AS PER MRCP

- Proximal third of CBD
- Middle third of CBD
- Distal third of CBD
- Hilar
- Intrahepatic
- Normal
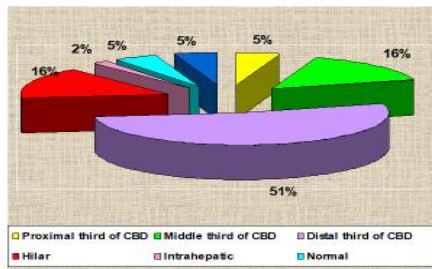
AGREEMENT IN LEVEL OF OBSTRUCTION AND CAUSE OF OBSTRUCTION
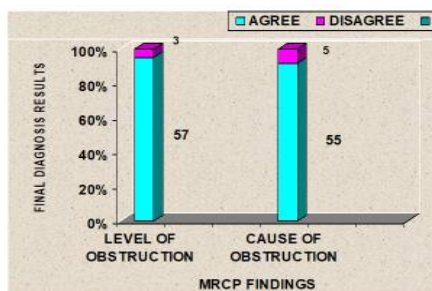
RELATIONSHIP BETWEEN CECT FINDINGS AND FINAL DIAGNOSIS REGARDING LEVEL OF BLOCK
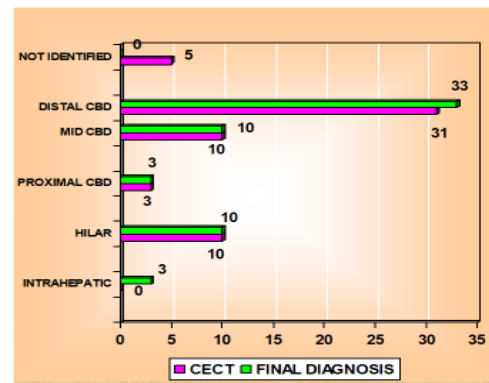
RELATIONSHIP BETWEEN MRCP FINDINGS AND FINAL DIAGNOSIS REGARDING LEVEL OF BLOCK
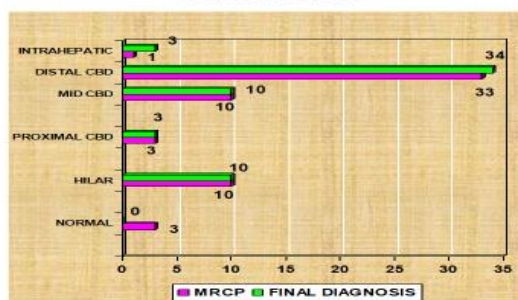
AGREEMENT IN CAUSE OF BLOCK
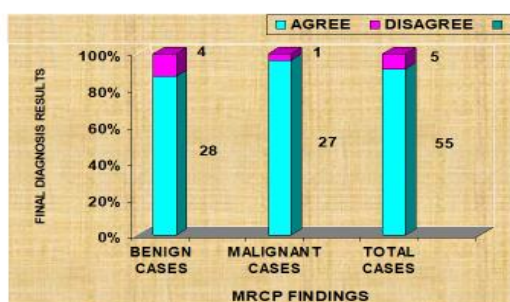
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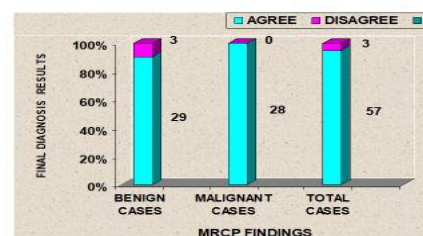
COMPARISON OF MRCP RESULTS WITH FINAL DIAGNOSIS
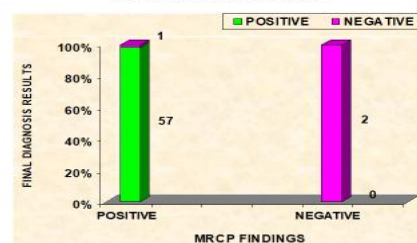
DISCUSSION

The present prospective study was conducted on sixty patients with clinical and biochemical evidence of biliary obstruction. The diagnosis and cause of biliary obstruction often relies on direct cholangiographic techniques such as endoscopic retrograde cholangiography or percutaneous transhepatic cholangiography. The added advantage of these techniques is their capability to provide therapeutic options at the same session. However, both

these techniques are invasive and associated with risk of complications.

Percutaneous transhepatic cholangiography or endoscopic retrograde cholangiography require experience and technical skill thus, the success rates vary between 68-98% in PTC and 70-90% in ERCP (36). ERCP is highly operator dependant with unsuccessful cannulation of common bile duct (CBD)/ pancreatic duct (PD) in 3-9% of cases. There is limited or no opacification of ducts proximal to a severe or complete obstruction. It is an invasive procedure with morbidity and mortality rates of 1-7% and 0.2-1% respectively. In percutaneous cholangiography, overall complication rate is 3.5%. The common serious complications include sepsis (1.4%), bile leak (1.45 %) and intraperitoneal hemorrhage (0.35%), pneumothorax, hepatic arteriovenous fistula, reaction to contrast media and death (0.2%) [37]. So, any other modality of selecting patients who require these procedures for therapeutic use would be advantageous [38].

In clinical perspective, the non-invasive diagnosis of choledocholithiasis is based on combination of clinical suspicion (biliary colic with jaundice, and /or cholangitis), biochemical analysis (raised bilirubin and alkaline phosphatase) and imaging findings (sonography with or without computed tomography). Unfortunately, all these tests have varying diagnostic accuracies, and there is no single method of uniformly identifying patients with bile duct calculi or any other cause of biliary obstruction [38]. Magnetic resonance cholangiopancreatography is a promising new technique that is able to produce highly accurate cholangiographic images, similar to direct cholangiography and yet combine the patient comfort and safety associated with sonography [38]. MRCP uses imaging sequences that provide direct cholangiograms and pancreatograms by using heavily T2 weighted sequences. Dilated intra-hepatic and extra-hepatic bile ducts are demonstrated as structures of high signal intensity, compared with the surrounding liver and pancreas. Initial studies with MRCP were performed with gradient – echo sequence by using 2D or 3D steady state free precession sequence [39-41]. These showed the feasibility for imaging to demonstrate bile duct obstruction and the anatomic features of the bile ducts proximal to even severe or complete obstructions. A major limitation of these sequences, however, was the inability to depict non- obstructed systems routinely. This was because fast gradient–echo sequences yielded a fairly low signal to noise ratio and required thick sections and a large field of view, which compromises visualization of small ducts [5].

Recently use of fast spin -echo and its variants combined with the use of phased array body coil has resulted in routine visualization of non-dilated ducts. Reinhold *et al.* compared the results of a 2D fast spin - echo T2 weighted pulse sequence with those of a 3D steady–state free precession sequence in a series of 26 patients., including 17 patients with a normal sized CBD, and obtained superior results with the fast spin - echo sequence [42]. Takehara *et al.* also used a fast spin -echo sequence to image pancreatic duct in 39 patients with chronic pancreatitis (43). On the basis of these results, Guibaud *et al.* used fast spin-echo and a body coil but obtained images in multiple planes instead of single coronal plane, and were able to visualize extrahepatic bile ducts in all 126 patients regardless of the presence of dilatation. They also used multiplanar reformatting and 3D maximum intensity projection (MIP) reconstructions. Their results in biliary obstruction were a sensitivity of 91%, specificity of 100% and diagnostic accuracy of 94% [5]. Reinhold *et al.*, documented 90% sensitivity and 100% specificity in a population of 110 patients with biliary obstruction using breathing –averaged 2D FSE sequences and a phased array coil [42]. Varghese *et al.*, obtained similar results with sensitivity of 93% and specificity of 99% in a population of 110 patients [38].

Using breath-hold single slice projection and thin multislice HASTE (half Fourier acquisition single – shot turbo spin echo) sequence with a phased array coil, Fulcher *et al.*, in 1998 found 100% sensitivity and specificity in a population of 265 patients investigated for biliary obstruction [44]. In a similar study de Ledinghen *et al.*, in 1999 reported a sensitivity of 100% and a specificity of 73% using HASTE sequence and phased array coil in 42 patients [44].

Jaundice was the most common symptom (85%) in our study, followed by pain in right hypochondrium (71.7%), nausea (35%), loss of appetite (23.3%) and pruritis (20%). In our study, MRCP was performed using T2W TSE (TR-411.7 ms,TE-80 ms and flip angle 90) with thick and thin slab multislice techniques in coronal and axial planes on a phased array body coil, Single Shot radio SE Sequences (sshMRCPrad,TR-8000 ms,TE-800 ms and flip angle 90), MRCP 3D(TR-1435.2 ms,TE-650 ms and flip angle 90)and MRCP 3D MIP, T2 SPAIR(TR-412.8 ms,TE-80 ms and flip angle 90) and BTFE (TR-3.9 ms,TE-1.9 ms and flip angle 90). For MRCP, thick slabs (40 mm) through the porta hepatis in coronal and coronal oblique planes were planned rotating around a point anterior to the portal vein. This technique allowed successful unraveling of the obliquely oriented and sometimes tortuous extrahepatic bile ducts. The main drawback of the single –section acquisition is that ductal visibility may be degraded by overlap with other fluid containing structures such as bowel, gall bladder, any cyst or ascites included in the field of view. Patients were fasted for minimum of six hours prior to the study to avoid fluid in bowel or stomach. No oral contrast was used in any of the patients.

To supplement, thin slices (8 mm thickness without any gap) were also acquired through the porta hepatis in coronal oblique or true coronal planes, depending upon the plane in which the biliary anatomy was best demonstrated in thick slab images. Post processing of the source images was obtained by using maximum intensity projection and multiplanar reformation algorithms. With this technique, section misregistration artifacts and cross-talk from adjacent sections are avoided and the bile and pancreatic ducts can be easily followed sequentially through their entire course. The thin section sequences were particularly useful for detection of small calculi as sensitivity for calculus detection decreases with an increase in section thickness owing to the volume averaging of high signal intensity bile surrounding the calculus. The level of obstruction and the cause of obstruction were well depicted with MR cholangiography.

Level of Obstruction

The level of obstruction was in agreement with direct final diagnosis in 57 of 60 cases with sensitivity of 100 % and diagnostic accuracy of 98.3 %. The correlation between MRCP and ERCP in the diagnosis of level of obstruction was 0.9335. The reported accuracy of MRCP in diagnosing the level of obstruction has been reported as a wide range of 77 % to 100 % [39, 45, 46]. Using 3D SSFP sequence, accuracy of 89 % was obtained in diagnosing the level of obstruction. A higher accuracy of 100 % for level of obstruction was reported using a breath-hold SS RARE sequence [17]. The results obtained in our study were comparable to literature. There were three discrepancies. Two case was found non-obstruction in case of intrahepatic cholestasis and one case of benign biliary stricture. Irie *et al.* in 2001 reported that contraction of the choledochal sphincter might be misinterpreted as an impacted calculus or stricture in distal bile duct [10].

In our study, hilar block was diagnosed in 10 cases (16.7 %) by MRCP. These were confirmed by ERCP or surgery. Out of these, two were due to gall bladder carcinomas with local infiltration, one was benign stricture and rest was due to hilar Cholangiocarcinoma (Klatskin's tumour). MRCP has proved accurate for defining the extent of hilar and perihilar biliary ductal involvement [37, 32]. Using direct cholangiography as the standard of reference, MRCP was adequate in predicting the Bismuth grade of biliary ductal involvement in 78-96% of patients. MRCP findings can be useful for selecting the side for access to the biliary system and type of drainage required. It also helps in planning technical aspects of drainage and associated risks [46].

CAUSE OF OBSTRUCTION

Majority of the cases of biliary obstruction are due to strictures or choledocholithiasis, either benign or malignant. The cause of obstruction was in agreement with the final diagnosis in 55 of the 60 cases with sensitivity of 92.30% and diagnostic accuracy of 95%. The correlation between MRCP and final diagnosis in the diagnosis of cause of obstruction was 0.8855. Similar results have been mentioned in literature. MRCP has been shown to be accurate in diagnosing the cause of obstruction, with positive predictive value of 93 % for benign causes and 86 % for malignant causes [47].

Choledocholithiasis

Choledocholithiasis accounts for most cases of obstruction of bile ducts. Direct cholangiography is generally still considered to be the ideal method for diagnosing CBD calculi. As ERCP may miss small calculi endoscopic sphincterotomy involving instrumental exploration is usually required to rule them out, especially in a dilated CBD. Success rates for cannulation and endoscopic sphincterotomy vary from 90 to 96%. Reported associated morbidity and death rates range between 9.8% & 13%, and 2.3% & 4% respectively. Thus, to avoid sphincterotomy related complications, careful patient selection is needed before ERC to prevent unnecessary sphincterotomies [46]. Endoscopic ultrasound (EUS) has been reported to be the best imaging technique to establish the diagnosis of choledocholithiasis with sensitivity of 97-98% and specificity of approximately 100% [48]. EUS can thus be an alternative to MRCP in the diagnosis of choledocholithiasis. However, this is an invasive technique requiring endoscopy and sedation [15]. On MRCP calculi are identified as signal voids within the high signal intensity fluid in the bile ducts. The differential diagnosis of these signal voids could be air bubbles, blood clots, sludge ball, flow voids and susceptibility artifacts from surgical clips.

In our study, choledocholithiasis was the final diagnosis as the cause of obstruction in 7 patients (11.7%) out of 60 cases. In addition, 2 cases showed calculi in CBD in addition to the primary cause of obstruction. The sensitivity, specificity and accuracy, for MRCP in the diagnosis of choledocholithiasis were 100 %, 96.2% and 95 % respectively. The positive predictive value and negative predictive values were 77.8 % and 100 % respectively. In two of the cases calculi was diagnosed as additional finding on MRCP. On was stricture due portal biliopathy (case no 57) and other (case no-60) was secondary calculus in case of choledochal cyst in pregnant lady, who gave history of jaundice from the age of seven. Use of ERCP as a reference is not without limitations [49]. Prat *et al.* found that 11% of bile duct calculi were missed by purely diagnostic ERCP when compared with sweeping the duct after endoscopic sphincterotomy [50].

CHOLELITHIASIS

In our study, cholelithiasis was diagnosed in 7(21.8%) patients, which were diagnosed on USG in all. All patients except two underwent cholecystectomy and

surgical confirmation was obtained. USG remains the imaging method of choice for diagnosis of gall bladder pathology. Although, MRCP can also depict gallstones, an additional study may be needed to differentiate gallstones from other causes of filling defects. As MRCP can detect gallstones and as well as coexisting cystic duct anomalies or their variants, intraoperative complications can be avoided with prior knowledge of exact anatomy. This technique can also help to determine the presence and extent of neoplastic diseases of gall bladder [51].

STRICTURE

Stricture of the bile duct could be due to benign or malignant cause. Neoplasms obstructing the biliary or pancreatic duct may arise from the ductal epithelium or involve the ducts by extension from primary or metastatic tumours of the liver, gall bladder, pancreas, or adjacent lymph nodes. Knowledge of the level and cause of obstruction is critical to treatment planning. A major advantage of MRCP is the ability to image the bile duct proximal to a stricture, which may not be possible with ERCP. This information can be helpful for planning the optimal drainage procedure, particularly for hilar tumours

In our study, stricture was diagnosed by MRCP as the cause of obstruction in 49 of 60 patients. The final diagnosis included 21 benign and 28 malignant strictures. Among the benign cases 3 cases the level of obstruction is not conclusively identified, in which two case was false negative. In our study strictures were diagnosed by MRCP with sensitivity, and diagnostic accuracy of 96.07% and 96.6% respectively. The reported sensitivity of MRCP for biliary strictures ranges from 78% to 100% [29, 30, 10]. Taylor *et al*., diagnosed strictures with sensitivity of 100 % and specificity of 99.1% [3]. The sensitivity and specificity of MRCP for diagnosing malignant strictures was 85 % and 71% respectively [7]. Comparable results were obtained in our study.

Benign Biliary Stricture

14 out of 16 benign biliary strictures were diagnosed correctly by MRCP. One was false negative. Two case was diagnosed benign biliary stricture secondary due to portal biliopathy (Case No-21, 57], liver biopsy in all these cases shows portal fibrosis. One

case (Case No 23) biopsy report shows hyperplastic mucus gland and absent malignant cells. Most of the cases in our study is found secondary due to chronic calcific pancreatitis. MRCP has been shown to be comparable to ERCP in demonstrating the location and extent of strictures of extrahepatic bile ducts with sensitivity of 91% -100% [45, 39, 46]. However, the diagnostic accuracy of strictures of intrahepatic bile ducts is still under investigation [47].

Malignant Biliary Stricture

Cholangiocarcinoma usually presents as a stricture. Although morphological features of benign and malignant strictures are defined, differentiation may be difficult at times. In study by Rosch *et al*., MRCP was as sensitive as ERCP in the sensitivity to diagnose malignant strictures, but both tests had limited specificity [7]. Gall bladder carcinoma is an important cause of perihilar biliary obstruction. The route of malignant spread is either from cystic duct to the CBD; from metastatic lymphadenopathy to the porta hepatis; or through hematogenous metastasis to the liver. MRCP enables the demonstration of filling defect within the gall bladder and the perihilar obstruction simultaneously. This helps in the decision making regarding the preferred access route for drainage, which depends on the exact location of stricture with respect to confluence.

In our study, one patient (Case No-3) was diagnosed as periampullary carcinoma, biopsy report shows ulcerated periampullary growth, patient was a known case of gastroesophageal reflux disease (Grade IV), another one patient was false negative, rest of the cases of periampullary carcinoma were diagnosed correctly. These could be distinguished correctly from CBD calculus due to the characteristic shape of obstruction. ERCP has an advantage over MRCP in evaluation of this area because ERCP allows direct visualization of this area [47]. MRCP has been shown to be as effective as ERCP for the detection of pancreatic carcinoma with sensitivity and specificity of 84 % and 97 % respectively for MRCP, and 70 % and 94 % respectively, for ERCP [52]. According to Motohara *et al*., T1–weighted gradient echo sequence acquired immediately following Gadolinium administration is the most consistent technique to demonstrate pancreatic carcinoma [52].

MASTER CHART

Table-1: Clinical Features and Biochemical Investigations

PoNo	AGE (Y) /SEX	CLINICAL FEATURES	S. BILI(T) (mg/dl)	S. BILI(C) (mg/dl)	ALK. PO4 (U/L)	ALT (U/L)	AST (U/L)	GGT (U/L)
1	77/M	Epigastric pain, nausea & jaundice	16.4	9.9	630	92	129	576
2	63/M	Abdominal pain, jaundice, constipation, itching and fever	3.2	1.9	886	107	81	765
3	85/M	Weight loss, jaundice, loss of appetite & Inability to take solid food.	19.4	7.4	696	152	123	635
4	50/F	Abdominal pain, jaundice, loss of appetite & weight loss	4.9	3.5	461	249	244	-
5	36/F	Abdominal pain, jaundice weight loss, loose stool & evening rise of temperature	14.1	8.6	210	54	73	47
6	55/F	Jaundice and loss of appetite	3.7	2.0	293	20		
7	80/F	Abdominal pain, vomiting & fever	0.6	0.2	150	31	50	93
8	47/M	Abdominal pain, vomitting & jaundice	1.9	0.9	603	124	33	1758
9	16/M	Upper abdominal pain, vomitting and weight loss.	2.0	1.2	386	82	25	177
10	28/F	Adbominal pain & jaundice	14.8	8.8	416	135	231	527
11	62/F	Jaundice, abdominal pain, fever and loss of appetite.	14.2	8.9	665	117	146	886
12	31/M	Itching, clay coloured stool, abdominal pain and yellow coloured urine.	27.2	16.9	246	45	77	61
13	71/M	Epigastric pain & jaundice.	4.1	2.4	600	216	117	368
14	24/M	Jaundice, right hypochondrium and epigastric pain, constipation	7.0	3.9	151	340	251	228
15	72/M	Jaundice, anorexia, clay coloured stool, weight loss & high coloured urine.	20.3	12.0	447	87	107	117
16	50/M	Upper abdomen pain, jaundice, vomiting & dysphagia for solid.	9.6	6.2	594	57	-	-
17	29/M	Right hypochondrium pain, Jaundice & clay coloured stool.	8.4	5.2	239	177	100	152
18	39/M	Jaundice, loose stool and abdominal pain	8.2	5.1	338	70	61	59
19	55/M	High coloured urine, clay colored stool, itching & loss of appetite.	27.3	17.3	549	131	119	384
20	54/M	Right hypochondrium pain, jaundice and white stool	28.9	18.9	415	79	109	299
21	42/F	Jaundice, black coloured stool, fresh bleed from rectum & giddiness.	9.4	8.1	589	269	345	-
22	62/M	Right hypochondrium pain	2.9	1.1	86	62	55	89
23	43/M	jaundice	14.8	8.7	396	150	130	348
24	44/F	Pain in abdomen and back, vomitting.	4.9	3.5	493	149	139	-
25	50/F	Jaundice, pruritis and vomiting	3.4	2.0	419	325	337	-
26	63/M	Loose stool, abd. Pain, nausea, vomiting, loss of appetite and weight	3.9	2.1	208	71	-	-
27	49/F	Epigastric pain, Jaundice, vomiting and constipation	2.3	1.2	518	184	181	701
28	57/M	Abdomen pain, jaundice	2.0	1.4	534	234	129	-
29	83/M	Vomiting, constipation and loss of appetite	6.4	3.6	147	78	39	198
30	40/F	Pain abdomen, jaundice, vomiting and pedal edema	6.7	3.9	176	42	95	48
31	58/M	Jaundice, nausea, itching, white coloured stool & yellow urine.	10.5	5.3	216	185	183	205
32	75/F	Itching, high coloured urine, loss of appetite & weight.	13.2	8.3	747	40	101	398
33	54/M	Abdominal pain & bloating, decreased appetite, weight loss, dysphagia.	1.4	1.0	623	23	34	361
34	56/F	Pain abdomen, fever and jaundice	13.1	9.7	810	126	158	-
35	50/M	Itching, yellow coloured urine & anorexia	10.9	6.6	1375	105	109	468
36	46/M	Abdominal pain, vomiting & Jaundice	2.8	1.7	149	72	77	250
37	61/M	Abdominal pain & Jaundice	17.7	9.0	622	57	116	185
38	72/F	Abdominal pain, generalised itching & Jaundice	8.6	5.6	382	70	102	273
39	47/M	Abdominal pain, Jaundice nausea and vomiting.	17.2	9.0	381	50	64	73
40	78/M	Jaundice, fever	39	22	463	90	77	276
41	56/M	Abdominal pain, jaundice and fever	2.1	1.2	219	61	56	156
42	75/M	Abdominal pain, vomiting and fever	2.5	1.6	597	146	138	756
43	37/M	Jaundice, abdominal pain, vomiting and fever	11.7	9.0	381	50	64	73
44	59/M	Abdominal pain and jaundice	2.0	0.8	231	36	33	209
45	16/M	Abdominal pain and jaundice	9.0	6.4	206	102	82	257
46	76/M	Pain abdomen, Jaundice	4.9	4.0	658	144	139	-

47	16/M	Jaundice, fever and abdominal pain	22.6	13.3	316	1679	1761	15
48	35/F	Jaundice, acholic stool	2.1	1.1	208	390	242	218
49	50/M	Abdominal pain, jaundice, vomiting, constipation, itching and fever	22.7	14.0	515	203	241	1013
50	10/F	Jaundice, abdominal pain and vomiting.	9.8	5.9	415	184	113	268
51	75/F	Abdominal pain and bilious vomiting	8.2	6.3	423	44	35	-
52	73/M	Jaundice, abdominal pain, nausea and vomiting	9.8	6.0	359	100	98	164
53	76/M	Jaundice, loss of appetite and pruritis.	2.0	0.8	43	17	26	80
54	37/M	Abdominal pain and jaundice	2.9	1.3	152	270	232	243
55	60/M	Jaundice, abdominal pain, loss of appetite and weight, abdominal distension, pedal edema.	15	7.9	558	62	163	151
56	65/M	Yellow discolouration of urine, abdominal discomfort, cough and loss of appetite.	17.8	9.8	557	55	130	127
57	22/M	Itching, vomitting, hematemesis and jaundice.	13.3	7.6	87	44	57	24
58	56/M	Jaundice, Pain and fever	2.5	1.6	597	138	146	-
59	75/F	Jaundice, abdominal pain, loss of appetite and weight, constipation, weakness	2.3	1.1	550	61	76	247
60	24/F	Rt. hypochondrium pain, vomiting, jaundice, itching and fever	4.2	2.3	217	33	37	61

Table-2: MRCP Findings

PoNo	IHBRD	CONFLUENCE	DILATED CBD	LEVEL OF BLOCK	CAUSE OF BLOCK	CALCULUS/ MASS IN CBD	GB	ADDITIONAL FINDINGS
1	+	+	-	P	CC	-	Distended	Periampullary diverticulum
2	+	+	+	M & D	PAC	-	distended, calculus of size 2.3 mm	Multiple nodal and liver deposits.
3	+	+	+	D	PAC	-	distended	-
4	+	-	-	Hilar	Ca.GB	-	Polypoidal mass in fundus	Liver mets
5	+	+	+	D	PAC	-	normal	Multiple liver mets and dilated MPD
6	+	+	+	D	PAC	sludge	Distended	Multiple liver mets and dilated MPD
7	+	+	+	D	CDC	-	normal	-
8	+	+	+	D	BBS	-	normal	-
9	+	+	+	D	BBS	-	overdistended	Hepatomegaly, pancreatic pseudocyst
10	+	+	+	M	External compression	-	Normal	Hemoperitoneum, omental metastasis, nodal mass
11	+	+	+	D	PAC	-	distended	Enlarged periportal lymph nodes.
12	-	-	-	Hilar	CC	-	Moderately distended	-
13	-	-	-	ND	ND	-	Multiple GB calculi largest1.3mm	Rt.lobe liver hemangioma.
14	+	+	+	D	BBS	-	9mm GB calculus	-
15	+	+	+	D	PAC	mass	Contracted.	MPD dilated and beaded appearance.
16	+	+	+	D	PAC	-	Calculus 13mm	Partial thrombosis of portal vein, left inguinal hernia, gross ascites, extensive omental thickening
17	+	+	+	D	PAC	-	Distended	Peripancreatic lymph node, liver mets
18	+	+	+	D	PAC	-	Distended	MPD dilated
19	+	-	-	Hilar	CC	-	Distended	-
20	+	-	-	Hilar	CC	-	Sludge+ calculus 10mm	Multiple liver mets, multiple lymph nodes at porta and peripancreatic region.
21	+	+	+	M	BBS-PB	-	distended	Chronic portal vein thrombosis, portal cavernoma transformation
22	+	+	+	D	BBS	-	Tumefactive sludge+2 GB calculi	HCV related cirrhosis, Splenomegaly, B/L pleural effusion, pericholecystic

								minimal fluid and omental adhesion
23	+	+	+	D	BBS	Sludge	Overdistended sludge	-
24	+	+	+	D	PAC	-	Overdistended	Chronic calcific pancreatitis and head mass, grossly dilated MPD, Chronic portal vein thrombosis and portal cavernoma transformation
25	+	+	+	D	BBS	-	Overdistended + Multiple GB calculi	-
26	+	+	+	M	PAC	-	normal	Ca. Pancreas with liver mets, Hepatomegaly.
27	+	+	+	M	C	3.2cm Calculus	Distended	-.
28	+	+	-	P	External compression	-	Normal	-
29	+	+	+	D	PAC	-	Distended	Ca. head of pancreas.
30	+	+	-	Intrahepatic	Hepatitis	-	GB wall edema.	Hepatosplenomegaly, few enlarged lymph nodes in porta,B/L MRD
31	+	+	+	M	CC	mass	Distended, multiple calculi, minimal wall thickening and wall thickening-calculus cholecystitis	-
32	+	+	-	Hilar	Hilar CC	mass	normal	-
33	+	+	+	D	PAC	-	distended	Invasive squamous cell carcinoma of distal esophagus, multiple enlarged paraaortic, peripancreatic and celiac lymph nodes.
34	+	+	+	D	C	Calculus of~8 mm	Wall thickening +sludge	Diverticulum from 2nd part of duodenum.
35	+	-	-	Hilar	BBS	-	-	Pancreatic duct not dilated.
36	+	+	+	D	C	8mm calculus	Surgically absent	-
37	+	-	-	Hilar	CC	-	-	Multiple enlarged lymph nodes in porta hepatis, paraaortic and paracaval
38	+	+	+	D	PAC	-	Distended +sludge	-
39	+	+	+	M	Hilar CC	-	Distended calculus	Multiple lymph nodes at porta and peripancreatic region
40	+	+	+	M	C	Calculus 1.4 x 1 cm	Multiple calculi 4-5 mm	-
41	+	+	+	D	C	Multiple calculi ~3 mm .	Multiple small calculi+ PUS in gb	-
42	+	+	+	M	C	Multiple calculi 2-3 mm	Multiple calculi 2-3 mm	Biliary Pancreatitis
43	+	+	+	D	PAC	-	Distended+sludge	MPD not dilated
44	+	+	+	D	BBS	-	Distended+sludge	Pancreatic calculi of size 4mm, peripancreatic free fluid.
45	+	-	-	ND	BBS	Thick walled CBD	Overdistended, sludge and pericholecystic collection	Focal acute Pancreatitis.
46	+	+	+	D	BBS	-	Multiple calculi, largest 7 mm.	B/L MRD
47	+	-	-	ND	BBS	-	Contracted	Few lymph nodes at porta and periportal cuffing.
48	+	+	+	D	CDC	-	normal	-
49	+	+	+	D	BBS	-	normal	-
50	+	+	+	D	BBS	-	Moderately	Chronic calcific pancreatitis

							distended	
51	+	+	+	D	BBS	-	Normal	-
52	+	+	-	P	Ca.GB	-	Mass	Multiple enlarged lymph nodes in porta hepatis, paraaortic, celiac axis and peripancreatic.
53	+	+	-	Hilar	Ca.GB	-	Mass	Enlarged paraaortic and peripancreatic lymph nodes
54	+	+	+	D	BBS	-	distended	Calculus of size 5 mm in uncinate process, chronic pancreatitis
55	+	-	-	Hilar	Hilar CC	mass	Infiltrated	Gross ascites
56	+	+	+	D	PAC	-	distended	-
57	+	+	+	D	BBS-PB	Tiny calculus	Distended with sludge	Liver cirrhosis, splenomegaly with gamma gandy bodies, multiple collateral venous channel and cavernous transformation of portal vein.
58	+	+	+	M	C	8.8 and 8.5 mm calculus	Moderately distended	Fatty liver
59	+	-	-	Hilar	Hilar CC	mass	Infiltration	
60	+	+	+	D	CDC	2.5 X1.5 cm calculus	Moderately distended	Primigravida 33-34 wks, calculus in posterior branch of RHD, minimal ascites.

KEY: S. No.- serial number, ND-not identified, P- proximal third of CBD, M- middle third of CBD, D- distal third of CBD, CC- Cholangiocarcinoma, Ca GB- Carcinoma gall bladder, PAC- Periampullary carcinoma, BBS-Benign biliary stricture, PB-portal biliopathy, CDC-choledochal cyst

Table-3: Final Diagnosis (n=60)

PoNo	LEVEL OF BLOCK	CAUSE OF BLOCK	DILATED CBD	CALCULUS in GB/CBD	STRIC TURE	SURGERY/ HISTOPATHOLOGY
1	P	CC	-	-	+	Cholangiocarcinoma
2	M & D	PAC	+	Multiple gb calculi	+	Metastatic adenocarcinoma of head of pancreas
3	D	Ulcerated periampullary growth	+	_	+	Negative for malignant cell, (GERD grade IV)
4	Hilar	Ca. GB	_	_	+	Moderately differentiated adenocarcinoma GB.
5	D	PAC	+	-	+	Pancreatic carcinoma.
6	D	PAC	+	_	+	Metastatic carcinoma head of pancreas.
7	D	CDC	+	-	+	Choledochal cyst.
8	D	BBS	+	_	+	Benign biliary stricture.
9	D	BBS	+	-	+	Chronic pancreatitis.
10	M	External compression	+	-	-	Nodal mass.
11	D	PAC	+	_	+	Well differentiated pancreatic adeno-carcinoma.
12	Hilar	CC	-	-	+	Cholangiocarcinom, (moderately differentiated adenocarcinoma).
13	Intrahepatic	Intrahepatic cholestasis.	_	Multiple gb cal larger1.3 cm	_	Intrahepatic cholestasis.
14	D	BBS	+	gb cal- 9 mm	+	Benign biliary stricture.
15	D	PAC	+	_	+	Adenocarcinoma.
16	D	PAC	+	gb cal 13 mm	+	Moderately differentiated adenocarcinoma
17	D	PAC	+	_	+	Ductal adenocarcinoma of pancreatic head.
18	D	PAC	+	_	+	Ductal adenocarcinoma of pancreatic head.
19	Hilar	CC	-	_	+	Cholangiocarcinoma.
20	Hilar	CC	-	gb cal -1.7 mm	+	Metastatic cholangiocarcinoma.
21	M	BBS-PB	+	-	+	Not done.
22	D	BBS	+	Two gb cal ~8 mm	+	Chronic cholecystitis.
23	D	BBS	+	_	+	Hyperplastic mucosal gland.

24	D	PAC	+	_	+	Well differentiated pancreatic carcinoma.
25	D	BBS	+	Multiple gb cal ~7 mm	+	Benign biliary stricture.
26	M	PAC	+	_	+	Adenocarcinoma pancreatic head.
27	M	C	+	CBD cal 3.2 cm	-	Choledocholithiasis.
28	P	External compression	-	-	-	Nodal mass at porta.
29	D	PAC	+	-	+	Ca head of pancreas.
30	Intrahepatic	Hepatitis	-	GB wall edema	-	Hepatosplenomegaly, few enlarged lymph nodes in porta, B/L MRD
31	M	CC	+	Multiple gb cal	+	Cholangiocarcinoma (Well differentiated papillary adenocarcinoma).
32	Hilar	Hilar CC	_	_	+	Cholangiocarcinoma
33	D	PAC	+	_	+	Not done.
34	D	C	+	CBD cal 8 mm	_	Choledocholithiasis.
35	Hilar	BBS	_	_	+	Not done.
36	D	C	+	CBD cal 8 mm	-	Choledocholithiasis.
37	Hilar	CC	_	_	+	Cholangiocarcinoma
38	D	PAC	+	_	+	Biopsy not done.
39	M	Hilar CC	+	Multiple tiny calculi+ sludge	+	Cholangiocarcinoma.
40	M	C	+	CBD cal 1.4x1.0 cm	-	Choledocholithiasis.
41	D	C	+	Multiple small calculi+ PUS in gb & CBD calculi.	-	Choledocholithiasis. And acute cholecystitis.
42	M	C	+	Multiple small calculi in gb & CBD calculi (2to3 mm)	-	Cholecystitis, choledocholithiasis. and biliary pancreatitis.
43	D	PAC	+	-	+	Well differentiated papillary adeno carcinoma.
44	D	BBS	+	-	+	Benign biliary stricture and chronic calcific (4 mm calculus in head region) pancreatitis.
45	D	BBS	-	-	+	Chronic atrophic pancreatitis.
46	D	BBS	+	Multiple GB calculi, largest 7mm	+	Benign biliary stricture
47	Intrahepatic	Acute viral hepatitis	+	-	+	IgM+ve HEV.
48	D	CDC	+	-	+	Choledochal cyst
49	D	BBS	+	-	+	Benign biliary stricture
50	D	BBS	+	-	+	Benign biliary stricture
51	D	BBS	+	-	+	Benign biliary stricture
52	P	CaGB	-	-	+	Adenocarcinoma GB
53	Hilar	CaGB	-	-	+	Adenocarcinoma GB
54	D	BBS	+	gb cal 6 mm	+	Benign biliary stricture
55	Hilar	Hilar CC	-	-	+	Cholangiocarcinoma.
56	D	PAC	+	-	+	Well differentiated adenocarcinoma.
57	D	BBS-PB	+	CBD cal 2mm	+	Portal cirrhosis.
58	M	C	+	CBD cal 8.8mm & 8.5mm.	-	Choledocholithiasis.
59	hilar	Hilar CC	-	-	+	Cholangiocarcinoma.
60	D	CDC	+	CBD Calculus 2.5 x 1.5 cm	+	Type 1 choledochal cyst with secondary calculus in CBD and posterior branch of RHD

Table-4: USG and CT Findings

PoNo	USG			CT		
	LEVEL OF BLOCK	CAUSE OF BLOCK	ADDITIONAL	LEVEL OF BLOCK	CAUSE OF BLOCK	ADDITIONAL
1	hilar	CC	GB distended	Hilar	CC	Periampullary diverticulum
2	M	PAC	Multiple nodal and liver deposits. GB calculus- 2.3 mm	M	PAC	Multiple nodal and liver deposits. GB calculus- 2.3 mm
3	D	PAC	-	D	PAC	-
4	Hilar	CaGB	Liver infiltration, portal nodes	Hilar	CaGB	Liver infiltration and multiple lymph nodes at porta and celiac axis
5	ND	ND	Multiple liver mets	D	PAC	Multiple liver mets.
6	D	PAC	Multiple liver mets	D	PAC	Multiple liver mets and right lung nodules, atrophic pancreatic parenchyma
7	D	CDC	-	D	CDC	-
8	D	BBS	1.2 cm calculus in head of pancreas	D	BBS	Chronic calcific pancreatitis.
9	D	BBS	Hepatomegaly	D	BBS	Hepatomegaly, pancreatic pseudocyst.
10	ND	ND	Hemoperitoneum, omental caking	M	Nodal mass	Hemoperitoneum, multiple enlarged perigastric and superior mesenteric lymph node
11	D	ND	Hypoechoic pancreatic head mass.	D	PAC	Heterodense pancreatic head mass, enlarged periportal lymph node.
12	Hilar	CC	-	Hilar	CC	-
13	ND	ND	Multiple GB calculus, largest 1.3 cm	ND	ND	Rt. lobe liver hemangioma, Multiple GB calculus
14	D	BBS	GB calculus, 9 mm	D	BBS	Chronic cholecystitis
15	D	PAC	-	D	PAC	-
16	D	PAC	GB Calculus, gross ascites, omental thickening	D	PAC	GB Calculus, gross ascites, omental thickening
17	D	ND	-	D	PAC	Heterogenous mass4.3x4.1cm in pancreatic head, liver mets seg.IV
18	ND	ND	-	D	PAC	-
19	Hilar	CC	-	Hilar	CC	-
20	Hilar	CC	GB calculus and sludge	Hilar	CC	GB calculus, multiple liver mets, multiple lymph nodes at porta and peripancreatic region.
21	M	PB	Chronic portal vein thrombosis, portal cavernoma transformation	M	PB	Chronic portal vein thrombosis, portal cavernoma transformation
22	D	BBS	Cirrhosis, Splenomegaly, B/L pleural effusion, thick GB wall and calculi.	D	BBS	Cirrhosis, Splenomegaly, B/L pleural effusion, GB calculi, pericholecystic minimal fluid and omental adhesion
23	D	BBS	-	D	BBS	
24	D	ND	-	D	PAC	Chronic calcific pancreatitis and head mass, grossly dilated MPD, Chronic portal vein thrombosis and portal cavernoma transformation
25	D	BBS	Multiple GB calculi.	D	BBS	Multiple GB calculi, Mild MPD dilatation.
26	M	PAC	Hetroechoic mass of size 3x2.2cm with Cystic dilatation of distal pancreatic duct, hepatomegaly	M	PAC	Ca. Pancreas with liver mets, Hepatomegaly
27	M	C	Multiple GB calculi + Sludge	M	C	Chronic cholecystitis
28	P	External compression	-	P	External compression	Nodal mass

29	D	ND	-	D	PAC	-
30	Intrahepatic	Hepatitis	Hepatosplenomegaly	ND	ND	Hepatosplenomegaly
31	M	CC	Distended, multiple calculi	M	CC	Distended, multiple calculi
32	Hilar	Hilar CC	-	Hilar	Hilar CC	-
33	D	PAC	Enlarged peripancreatic nodes	D	PAC	Invasive squamous cell carcinoma of distal esophagus, multiple enlarged paraaortic, peripancreatic and celiac lymph nodes.
34	D	ND	GB wall thickening +sludge	D	C	Diverticulum from 2nd part of duodenum.
35	Hilar	Hilar stricture		Hilar	Hilar stricture	-
36	D	C	-	D	-	-
37	Hilar	Hilar CC	Lymph nodes	Hilar	Hilar CC	Multiple enlarged porta, paraaortic Lymph nodes, Rt mild HUN due to lower ureteric stricture.
38	M	ND	-	D	PAC	-
39	M	Hilar CC	-	M	Hilar CC	Enlarged lymph at porta and peripancreatic.
40	M	calculus	GB cal	M	calculus	GB cal
41	D			D		
42	M	Calculus	GB cal	M	calculus	GB cal
43	D	ND	MPD dilated	D	PAC	MPD dilated
44	D	ND	GB Sludge	D	ND	Chronic calcific pancreatitis.
45	ND	ND	Overdistended, sludge and Chronic pancreatitis	D	ND	Dilated MPD
46	ND	ND	IHBR and proximal CBD dilated distal part obscured by bowel gas, b/l MRD.	ND	ND	-
47	ND	ND	Few lymph nodes at porta and periportal cuffing	ND	ND	Few lymph nodes at porta
48	D	CDC	-	ND	CDC	-
49	D	BBS	-	D	D	-
50	D	BBS	-	D	BBS	Chronic calcific pancreatitis
51	D	BBS	-	D	BBS	-
52	P	CaGB	Multiple enlarged lymph nodes in porta hepatis, paraaortic, celiac axis and peripancreatic.	P	CaGB	Multiple enlarged lymph nodes in porta hepatis, paraaortic, celiac axis and peripancreatic.
53	D	CaGB	-	D	CaGB	-
54	D	BBS	Calculus of size 5 mm in uncinate process, chronic pancreatitis	D	BBS	Calculus of size 5 mm in uncinate process, chronic pancreatitis
55	Hilar	Hilar CC	Gross ascites	Hilar	Hilar CC	Gross ascites
56	D	PAC	-	D	PAC	-
57	D	PB	Liver cirrhosis, splenomegaly with gamma gandy bodies, multiple collateral venous channel and cavernous transformation of portal vein.	D	PB	Liver cirrhosis, splenomegaly with gamma gandy bodies, multiple collateral venous channel and cavernous transformation of portal vein.
58	M	C	-	M	C	-
59	Hilar	Hilar CC	-	Hilar	Hilar CC	-
60	D	CDC	Primigravida 33-34 wks, calculus in CBD and posterior branch of RHD, minimal ascites.	Not done	Not done	Not done

KEY: S. No.- serial number, ND-not identified, P- proximal third of CBD, M- middle third of CBD, D- distal third of CBD, CC-Cholangiocarcinoma, Ca GB- Carcinoma gall bladder, PAC- Periampullary carcinoma, BBS-Benign biliary stricture, PB-portal biliopathy, CDC-choledochal cyst

LIMITATIONS

The limitations of MRCP are low spatial resolution with difficulty in differentiating between benign and malignant strictures in absence of mass [23].

Overlapping of the biliary system by fluid in gastrointestinal system can be avoided by keeping the patient fasting, use of oral contrast and taking sections at different angles. Calculi may be mimicked by air,

biliary sludge or clot. En-face visualization of the cystic duct insertion or the confluence of right and left hepatic ducts may mimic intraluminal filling defects such as calculus. Contraction of the choledochal sphincter may be misinterpreted as impacted calculus or stricture in the distal bile duct. So, if a filling defect or stricture is suspected in the periampullary region, repeat MRCP should be performed [10]. Thus, a calculus can be reliably diagnosed only if it is surrounded by bile from all sides. A central linear signal void is often seen in CBD, mimicking a stent or worm in CBD which is possibly due to the flow of bile, which can be differentiated by the very low signal intensity. Subsegmental isolation may be missed in hilar blocks. Contrast may be required in differentiating benign from malignant strictures, and pancreatic from ampullary or low bile duct carcinomas.

Using current techniques, MRCP does not provide dynamic information. Another advance in MRCP is the use of contrast agents that are hepatocyte – selective and eliminated at least in part, by the biliary system. With these agents and faster acquisition with thin-section three-dimensional T1 weighted images of the biliary system, demonstration of smaller intrahepatic biliary branches is feasible. This approach may also facilitate detection of functional obstruction or bile duct injury or leak (1). MRCP is also done after secretin stimulation in chronic pancreatitis. Decreased duodenal filling after secretin in chronic pancreatitis was seen shown in a study by Manfredi *et al.*, [53].

In conclusion, in our study we found that MR cholangiography has the ability to display the biliary tree by combining the advantages of projectional and cross-sectional imaging. Projectional views can delineate the overall anatomy of the biliary tract, depict bile duct dilatation, localization and identification of the cause of biliary tract obstruction, with diagnostic accuracy very similar to that of direct cholangiography. The status of pancreas, pancreatic duct and gall bladder is also well shown on these images. However, detection of small calculi and subtle intraductal material may be limited on projectional MR images and direct cholangiography. So, the coronal thin section images were invaluable in the diagnosis of small calculi in the bile duct, pancreatic duct or the gall bladder.

The absence of consensus about which sequence is most appropriate for showing the cause of obstruction and the lack of outcome studies indicate that the technique is still evolving. The diagnostic accuracy of MR cholangiography is expected to improve, as additional technical refinements on MR technology are likely [52]. Currently, MRCP has established itself as clinically useful and at par with ERCP for the evaluation of various biliary and pancreatic ductal diseases. MRCP has the tremendous advantage of being non-invasive. Furthermore, MR imaging is useful in patients with incomplete or failed ERCP, and in patients with certain biliary or gastroduodenal surgical procedures, it is the modality of choice [54].

ERCP will remain an extremely important modality because of the great clinical importance associated with this technique i.e. room for interventional procedures. Nonetheless, MRCP may in the near future replace most of the diagnostic imaging of the biliary tree, with diagnostic results even more improved with further developments of hardware and technique.

CONCLUSIONS

This prospective study was conducted on sixty patients with clinically suspected biliary obstruction. The patients were subjected to Magnetic Resonance Cholangiopancreatography and other imaging modalities and compared and correlated with final diagnosis and clinical profile. The conclusions drawn were:

- The incidence of biliary obstruction was found more common in male sex in our study
- The incidence of biliary obstruction was found more common in later middle ages.
- The commonest presenting symptom in these patients were jaundice, pain in right hypochondrium, pruritis, nausea, loss of appetite, and fever.
- Ultrasound is the best initial screening imaging modality for the biliary system.
- Ultrasound is a modality with high degree of specificity with good sensitivity for diagnosing the level and cause of biliary obstruction.
- Quality of USG depends both on operator variables i.e. experience and subject variables i.e. bowel gases and co-operation.
- CECT is a valuable modality in identifying the level of biliary obstruction and delineating the extent of neoplastic invasion.
- CT is a poor modality for identification of calculi in biliary tract.
- MR Cholangiography is a safe modality without the use of ionizing radiation and iodinated contrast agents.
- MR Cholangiography has the ability to display the biliary tree by combining the advantages of projectional and cross-sectional imaging.
- MRCP was comparable with Direct Cholangiography in identifying the level of block in 57 of 60 cases (95%)
- MRCP showed high sensitivity (100 %) and diagnostic accuracy (96.29 %) in identifying the level of block.
- MRCP is comparable with Direct Cholangiography in identifying the cause of block (calculus, benign and malignant strictures) in 55 of the 60 cases (91.6%).
- MRCP should be considered the investigation of choice in all cases of obstructive biliopathy

unless some interventional procedure is indicated.

- The pancreatic duct was visualized at least in part in 89 % of patients, MRCP is useful for noninvasive imaging of the pancreatic duct.
- The axial T2W TSE (TR-411.7 ms, TE-80 ms and flip angle 90^{deg}) image provided cross-sectional views, which were essential in the diagnosis of extraductal pathology, useful in the confirmation of intraductal pathology and for staging of malignancies.
- Quality of MRCP can be degraded by intraabdominal fluid – bowel fluids, or peritoneal collections.
- Oral negative contrast agents may be used to provide better images.
- A more complete MR examination that includes Gadolinium – enhanced T1 weighted sequences may be performed, if necessary, to diagnose a tumor mass and to ascertain the nature of stricture- benign or malignant.
- ERCP will remain an extremely important modality because of the great clinical importance associated with this technique i.e. room for interventional procedures.
- The limitations of MRCP are low spatial resolution with difficulty in differentiating between benign and malignant strictures in absence of mass.
- Contraction of the choledochal sphincter may be misinterpreted as impacted calculus or stricture in the distal bile duct. So, if a filling defect or stricture is suspected in the periampullary region, repeat MRCP should be performed.
- MRCP is still an evolving technique, it has established itself as clinically useful noninvasive investigation and comparable with direct cholangiography for the evaluation of various pancreatic or biliary ductal diseases.
- MRCP is not only comparable with direct cholangiography in its diagnostic ability, but it has the tremendous advantage of being noninvasive.

REFERENCES

1. Lee VS, Rofsky NM, Morgan GR, Teperman LW, Krinsky GA, Berman P, Weinreb JC. Volumetric mangafodipir trisodium-enhanced cholangiography to define intrahepatic biliary anatomy. American Journal of Roentgenology. 2001 Apr;176(4):906-8.
2. Regan F, Fradin J, Khazan R, Bohlman M, Magnuson T. Choledocholithiasis: evaluation with MR cholangiography. AJR. American journal of roentgenology. 1996 Dec;167(6):1441-5.
3. Baron RL, Stanley RJ, Lee JK, Koehler RE, Levitt RG. Computed tomographic features of biliary obstruction. American Journal of Roentgenology. 1983 Jun 1;140(6):1173-8.
4. Pisani JC, Bacelar A, Malafaia O, Ribas-Filho JM, Czezcko NG, Nassif PA. Comparative study between magnetic resonance cholangiopancreatography and endoscopic retrograde cholangiopancreatography in the diagnosis of the pancreatic and biliary obstruction. Arquivos de gastroenterologia. 2001;38(3):149-57.
5. Guibaud L, Bret PM, Reinhold C, Atri M, Barkun AM. Bile duct obstruction and choledocholithiasis. Diagnosis with MR Cholangiography. Radiology, 1995; 197:109-115.
6. Coakley FV, Schwartz LH. Magnetic resonance cholangiopancreatography. Journal Magn Reson Imaging, 1999; 9:157-162.
7. Rösch T, Meining A, Frühmorgen S, Zillinger C, Schusdziarra V, Hellerhoff K, Classen M, Helmberger H. A prospective comparison of the diagnostic accuracy of ERCP, MRCP, CT, and EUS in biliary strictures. Gastrointestinal endoscopy. 2002 Jun 1;55(7):870-6.
8. Mueller PR, Harbin WP, Ferruci JT, Wittenberg J van Sonnenberg E. Fine-needle transhepatic cholangiography: reflections after 450 cases. AJR, 1981; 136: 85-90.
9. Coakley FV, Qayyam A. Magnetic Resonance Cholangiopancreatography. Gastrointest Endoscopy, 2002; 55 (7Suppl): S2-12.
10. Irie H, Honda H, Kuroiwa T, Yoshimitsu K, Aibe H, Shinozaki K, Masuda K. Pitfalls in MR cholangiopancreatographic interpretation. Radiographics. 2001 Jan;21(1):23-37.
11. Yeh TS, Jan YY, Tseng JH, Chiu CT, Chen TC, Hwang TL, Chen MF. Malignant perihilar biliary obstruction: magnetic resonance cholangiopancreatographic findings. The American journal of gastroenterology. 2000 Feb 1;95(2):432-40.
12. Kim JH, Kim MJ, Park SI, Chung JJ, Song SY, Kim KS, Yoo HS, Lee JT, Kim KW. MR cholangiography in symptomatic gallstones: diagnostic accuracy according to clinical risk group. Radiology. 2002 Aug;224(2):410-6.
13. Khalid TR, Casillas VJ, Montalvo BM, Centeno R, Levi JU. Using MR cholangiopancreatography to evaluate iatrogenic bile duct injury. American Journal of Roentgenology. 2001 Dec;177(6):1347-52.
14. Lopera JE, Soto JA, Munera F. Malignant hilar and perihilar biliary obstruction: use of MR cholangiography to define the extent of biliary ductal involvement and plan percutaneous interventions. Radiology, 2001; 220: 90-96.
15. Laokpessi A, Bouillet P, Sautereau D, Cessot F, Desport JC, Le Sidaner A, Pillegand B. Value of magnetic resonance cholangiography in the preoperative diagnosis of common bile duct stones. The American journal of gastroenterology. 2001 Aug 1;96(8):2354-9.

16. Taylor ACF, Little AF, Hennessy OF, Banting SW, Smith PJ, Desmond PV. Prospective assessment of magnetic resonance cholangiopancreatography for noninvasive imaging of the biliary tree. Gastrointest Endosc, 2002; 55: 17-22.

17. Irie H, Honda H, Shinozaki K, Yoshimitsu K, Aibe H, Nishie A, Nakayama T, Masuda K. MR imaging of ampullary carcinomas. Journal of computer assisted tomography. 2002 Sep 1;26(5):711-7.

18. Schwartz LH, Black J, Fong Y, Jarnagin W, Blumgart L, Gruen D, Winston C, Panicek DM. Gallbladder carcinoma: findings at MR imaging with MR cholangiopancreatography. Journal of computer assisted tomography. 2002 May 1;26(3):405-10.

19. Tripathi RP, Batra A, Kaushik S. Magnetic resonance cholangiopancreatography: evaluation in 150 patients. Ind J Gastroenterol. 2002;21(3):105-9.

20. Kim TK, Kim BS, Kim JH, Ha HK, Kim PN, Kim AY, Lee MG. Diagnosis of intrahepatic stones: superiority of MR cholangiopancreatography over endoscopic retrograde cholangiopancreatography. American Journal of Roentgenology. 2002 Aug;179(2):429-34.

21. Calvo MM, Bujanda L, Calderón A, Heras I, Cabriada JL, Bernal A, Orive V, Capelastegi A. Role of magnetic resonance cholangiopancreatography in patients with suspected choledocholithiasis. InMayo Clinic Proceedings 2002 May 1; 77(5), 422-428.

22. Ke ZW, Zheng CZ, Li JH, Yin K, Hua JD. Prospective evaluation of magnetic resonance cholangiography in patients with suspected common bile duct stones before laparoscopic cholecystectomy. Hepatobiliary & pancreatic diseases international: HBPD INT. 2003 Nov;2(4):576-80.

23. Romagnuolo J, Bardou M, Rahme E, Joseph L, Reinhold C, Barkun AN. Magnetic resonance cholangiopancreatography: a meta-analysis of test performance in suspected biliary disease. Annals of internal medicine. 2003 Oct 7;139(7):547-57.

24. Weber C, Krupski G, Lorenzen J. MRCP in primary sclerosing cholangitis. Rafo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr, 2003; 175(2): 203-10.

25. Di EC, Puglielli E, Michelini O, Pistoi MA, Lombardi L, Rossi M, Barile A, Masciocchi C. Malignant obstructive jaundice: comparison of MRCP and ERCP in the evaluation of distal lesions. La Radiologia medica. 2003;105(5-6):445-53.

26. Kats J, Kraai M, Dijkstra AJ. Magnetic resonance cholangiopancreatography as a diagnostic tool for bile duct stones. A comparison with ERCP and clinical follow-up. Dig Surg. 2003;20:31-7.

27. Domagk D, Wessling J, Reimer P, Hertel L, Poremba C, Senninger N, Heinecke A, Domschke W, Menzel J. Endoscopic retrograde cholangiopancreatography, intraductal ultrasonography, and magnetic resonance cholangiopancreatography in bile duct strictures: a prospective comparison of imaging diagnostics with histopathological correlation. American Journal of Gastroenterology. 2004 Sep 1;99(9):1684-9.

28. Vaishali MD, Agarwal AK, Upadhyaya DN, Chauhan VS, Sharma OP, Shukla VK. Magnetic resonance cholangiopancreatography in obstructive jaundice. Clin Gastroenterol, 2004 Nov-Dec;38(10):887-90.

29. Makary MA, Duncan MD, Harmon JW, Freeswick PD, Bender JS, Bohlman M, Magnuson TH. The role of magnetic resonance cholangiography in the management of patients with gallstone pancreatitis. Ann Surg. 2005 Jan;241(1):119-24.

30. Shanmugam V, Beattie GC, Yule SR, Reid W, Loudon MA. Is magnetic resonance cholangiopancreatography the new gold standard in biliary imaging? Br Journal Radiol, 2005 Oct;78(934):888-93.

31. Hallal AH, Amortegui JD, Jeroukhimov IM, Casillas J, Schulman CI, Manning RJ, Habib FA, Lopez PP, Cohn SM, Sleeman D. Magnetic resonance cholangiopancreatography accurately detects common bile duct stones in resolving gallstone pancreatitis. Journal of the American College of Surgeons. 2005 Jun 1;200(6):869-75.

32. Zhou J, Liang B, Huang S, Liu Q. Comparison of MR cholangiopancreatography and surgical diagnosis of extrahepatic bile duct carcinoma. Zhonghua zhong liu za zhi [Chinese journal of oncology]. 2002 Jan;24(1):87-9.

33. Tajiri T, Yoshida H, Mamada Y, Taniai N, Yokomuro S, Mizuguchi Y. Diagnosis and initial management of cholangiocarcinoma with obstructive jaundice. World Journal of Gastroenterology: WJG. 2008 May 21;14(19):3000-3005.

34. Oto A, Ernst R, Ghulmiyyah L, Hughes D, Saade G, Chaljub G. The role of MR cholangiopancreatography in the evaluation of pregnant patients with acute pancreaticobiliary disease. The British journal of radiology. 2009 Apr;82(976):279-85.

35. Maccioni F, Martinelli M, Al Ansari N, Kagarmanova A, De Marco V, Zippi M, Marini M. Magnetic resonance cholangiography: past, present and future: a review. Eur Rev Med Pharmacol Sci. 2010 Aug 1;14(8):721-5.

36. Bilbao MK, Dotter CT, Lee TG, Katon RM. Complications of endoscopic retrograde cholangiopancreatography (ERCP): a study of 10,000 cases. Gastroenterology, 1976; 70:314-20.

37. Soto JA, Barish MA, Yucel EK, Siegenberg D, Ferrucci JT, Chuttani R. Magnetic resonance

cholangiography: comparison to endoscopic retrograde cholangiopancreatography. Gastroenterology. 1996; 110:589-97.

38. Varghese JC, Farell MA, Courtney G, Osborne h, Murray FE, Lee MJ. A prospective comparison of magnetic resonance cholangiopancreatography with endoscopic retrograde cholangiopancreatography in the evaluation of patients with suspected biliary tact disease. Clin Radiol, 1999; 54: 513-20.

39. Ishizaki Y, Wakayama T, Okada Y, Kobayashi T. Magnetic resonance cholangiography for evaluation of obstructive jaundice. Am Journal Gastroenterol, 1993; 88:2072-7.

40. Masci E, Toti G, Mariani A, Curioni S, Lomazzi A, Dinelli M, Minoli G, Crosta C, Comin U, Fertitta A, Prada A. Complications of diagnostic and therapeutic ERCP: a prospective multicenter study. The American journal of gastroenterology. 2001 Feb 1;96(2):417-23.

41. Wallner BK, Schumacher KA, Weidenmaier W, Friedrich JM. Dilated biliary tract: evaluation with MR cholangiography with a T_2-weighted contrast enhanced fat sequence. Radiology, 1991; 181:805-808.

42. Reinhold C, Guibaud L, Genin G, Bret PM. MR cholangiopancreatography: comparison between two-dimensional fast spin-echo and three-dimensional gradient-echo pulse sequences. Journal of Magnetic Resonance Imaging. 1995 Jul;5(4):379-84.

43. Takehara Y. Can MRCP replace ERCP? Journal Magn Reson Imaging, 1998; 8(3):517-34.

44. Fulcher AS, Turner MA, Capps GW, Zfass AM, Baker KM. Half Fourier RARE MR cholangiopancreatography: Experience in 300 subjects. Radiology, 1998; 207:21-32.

45. Hall-Craggs MA, Allen CM, Owens CM, Theis BA, Donald JJ, Paley M, Wilkinson ID, Chong WK, Hatfield AR, Lees WR. MR cholangiography: clinical evaluation in 40 cases. Radiology. 1993 Nov;189(2):423-7.

46. Lee MG, Lee JH, Kim MH. Extrahepatic biliary diseases: 3D MR cholangiopancreatography

compared with endoscopic retrograde cholangiopancreatography. Radiology, 1997; 181: 805-8.

47. 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.

48. Palazzo L, Girollet PP, Salmeron M, Silvain C, Roseau G, Canard JM, Chaussade S, Couturier D, Paolaggi JA. Value of endoscopic ultrasonography in the diagnosis of common bile duct stones: comparison with surgical exploration and ERCP. Gastrointestinal endoscopy. 1995 Sep 1;42(3):225-31.

49. Chan YL, Chan AC, Lam WW, Lee DW, Chung SS, Sung JJ, Cheung HS, Li AK, Metreweli C. Choledocholithiasis: comparison of MR cholangiography and endoscopic retrograde cholangiography. Radiology. 1996 Jul;200(1):85-9.

50. Prat F, Amouyal G, Amouyal P, Pelletier G, Fritsch J, Choury AD, Buffet C, Etienne JP. Prospective controlled study of endoscopic ultrasonography and endoscopic retrograde cholangiography in patients with suspected common-bileduct lithiasis. The Lancet. 1996 Jan 13;347(8994):75-9.

51. Fulcher AS, Turner MA, Capps GW. MR cholangiography: technical advances and clinical applications. Radiographics, 1999; 19:25-41.

52. Motohara T, Semelka RC, Bader TR. MR cholangiopancreatography. Radiologic Clinics. 2003 Jan 1;41(1):89-96.

53. Manfredi R, Costamagna G, Brizi MG, Maresca G, Vecchioli A, Colagrande C, Marano P. Severe chronic pancreatitis versus suspected pancreatic disease: dynamic MR cholangiopancreatography after secretin stimulation. Radiology. 2000 Mar;214(3):849-55.

54. Gallix BP, Regent D, Bruel JM. Use of magnetic resonance cholangiography in the diagnosis of choledocholithiasis. Abdom Imaging, 2001; 26:21-27.