Diagnostic role of magnetic resonance cholangiopancreatography in evaluation of obstructive biliopathies and correlating it with final diagnosis and clinical profile of patients

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Abstract

Aims and Objective: We assessed the utility of magnetic resonance cholangiopancreatography (MRCP) as a noninvasive diagnostic tool in patients with obstructive biliopathies. **Materials and Methods:** A prospective study was conducted on 54 patients with clinically suspected biliary obstruction. MRCP in these patients was compared and correlated with final diagnosis and their clinical profile. **Statistical Analysis:** Sample profile was described in terms of sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy. Pearson's Chi-square statistics was used to assess the strength of association between diagnostic accuracy of MRCP and final diagnosis. **Results:** Out of the 54 patients, 50 had biliary obstruction. The cause of biliary obstruction was finally identified on the basis of direct cholangiography/surgery/histopathology. In 52 of the 54 patients, MRCP agreed with final diagnosis in identifying the level of block. MRCP agreed with final diagnosis in identifying the cause of obstruction in 48 of the 54 patients (89%). Sensitivity of MRCP in identifying the level of obstruction in comparison with final diagnosis was 100%, while diagnostic accuracy of MRCP in identifying the level of obstruction in comparison with final diagnosis was 96.29%. The correlation between MRCP and final diagnosis in diagnosing cause of obstruction was 0.95 (Pearson's correlation coefficient, $P = 0.017$). **Conclusion:** MRCP is a safe ionizing radiation and iodinated contrast free modality which has the ability to display the biliary tree by combining the advantages of projectional and cross-sectional imaging.

Key words: Magnetic resonance cholangiopancreatography, obstructive biliopathy, malignant stricture, benign stricture, choledocholithiasis

INTRODUCTION

Diseases of the biliary tree and the pancreas are common in India and worldwide. Causes of bile duct obstruction may be benign (primary sclerosing cholangitis, AIDS cholangiopathy, postsurgical stricture, and hepatic artery chemotherapy) or malignant (cholangiocarcinoma, carcinoma of the head of pancreas, duodenal or ampullary carcinoma, or metastatic disease) and may be intraluminal (choledocholithiasis, hemobilia or parasites) or extraluminal (chronic pancreatitis, ampullary stenosis, lymph node compression, or vascular compression) in origin. Congenital causes include biliary atresia, choledochal cyst or Caroli's disease.[1] Imaging of biliary tree is to confirm the presence of obstruction and to accurately localize the site of obstruction which helps to initiate appropriate therapeutic measures.

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Noninvasive imaging modalities of biliary system include ultrasonography (USG) and computed tomography. Invasive methods include direct cholangiographic methods like endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC) and intraoperative cholangiography. Magnetic resonance cholangiopancreatography (MRCP) is a novel approach for biliary and pancreatic duct imaging, which uses MR imaging to visualize fluid in the biliary and pancreatic ducts as high signal intensity on heavily T2-weighted sequences. This technique is especially useful in neoplastic diseases of pancreatic or biliary ducts.[2] Furthermore, when MRCP is performed as part of a full abdominal examination, it can provide a one stop evaluation of nature and site of ductal disease and the extent and stage of any underlying tumor, including detection of any associated adenopathy or liver metastasis.[3] 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.

MATERIALS AND METHODS

A prospective study was conducted over the span of 1 year on 54 patients with clinically suspected biliary obstruction. MRCP was performed using GE 1.5T scanner single shot fast spin echo (SSFSE) sequence with thick and thin slab multislice techniques in coronal and oblique coronal planes on a phased array body coil. Additional axial MR images were obtained using SSFSE and fast spoiled gradient recalled echo (FSPGR) sequence. 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. No oral contrast was used in any of the patients. Additional 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. Postprocessing of the source images was obtained by using maximum intensity projection and multiplanar reformation algorithms. 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.

RESULTS

Fifty out of the 54 patients had biliary obstruction. The cause of biliary obstruction was finally identified on the basis of direct cholangiography/surgery/histopathology as choledocholithiasis (9 patients), periampullary carcinoma (6 patients), Mirrizzi's syndrome (3 patients), carcinoma of the gall bladder (9 patients), benign biliary stricture (12 patients), portal biliopathy, extrahepatic biliary atresia in one patient each, cholangiocarcinoma (5 patients) and external compression and choledochal cysts (2 patients each). No biliary obstruction was identified in four patients. All these patients underwent MRCP.

The results of MRCP were compared with ERCP in 21 patients, with operative and histopathological findings in 27 patients, with intraoperative cholangiography-operative findings in two patients, with T-tube cholangiography in three patients and with histopathological cum other radiological investigations in two patients. Therapeutic ERCP was done in nine patients.

Magnetic resonance cholangiopancreatography findings

Magnetic resonance cholangiopancreatography revealed intrahepatic biliary radical dilatation in 47 patients (87%) with patent confluence in 49 patients (90%), dilated common bile duct (CBD) in 35 patients (65%), absence of obstruction in 2 patients (4%) and hilar block in 5 patients (9.2%). Block was at the proximal third of CBD in 13 patients (24%), at mid-third in 15 patients (28%), and at distal third of CBD in 19 patients (34.5%).

Initial diagnosis suggested at magnetic resonance cholangiopancreatography

Choledocholithiasis was diagnosed in 15 patients among whom nine patients had obstruction. Stricture was diagnosed as the cause of obstruction in 54 patients, of which 22 were diagnosed as malignant and 30 were diagnosed as benign strictures. No obstruction was found in two patients. Among the 30 patients following causes were identified: Choledocholithiasis (9 patients [30%]) [Figure 1], benign biliary stricture (14 patients [42%]) [Figure 2], benign stricture due to portal biliopathy (1 patient [3.33%]) [Figure 3], external compression (2 patients [6.7%]) [Figure 4], extrahepatic biliary atresia (1 patient [3.33%]) [Figure 5a and b] and Mirrizzi's syndrome (3 patients [10%]). Cholelithiasis was diagnosed in 11 patients (37%) [Figure 6a and b]. Additional small calculi in CBD were identified in four patients with benign biliary stricture. Out of the 22 patients, periampullary carcinoma was identified as the cause in six patients (27%) [Figure 7a and 7b], carcinoma gall bladder in nine patients (41%) [Figure 8] and cholangiocarcinoma in seven patients (32%) [Figure 9]. Cholelithiasis was identified in four patients. Liver metastasis was diagnosed in six patients [Figure 10]. Retroperitoneal or periportal lymphadenopathy was diagnosed in six patients. Additional calculi in the CBD were seen in three patients. The pancreatic duct was

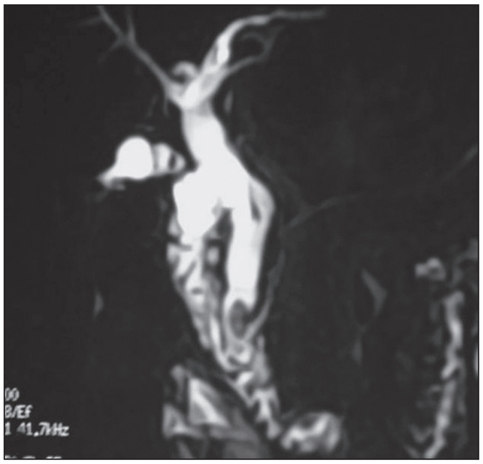

Figure 1: Magnetic resonance cholangiopancreatography image showing calculus in terminal common bile duct

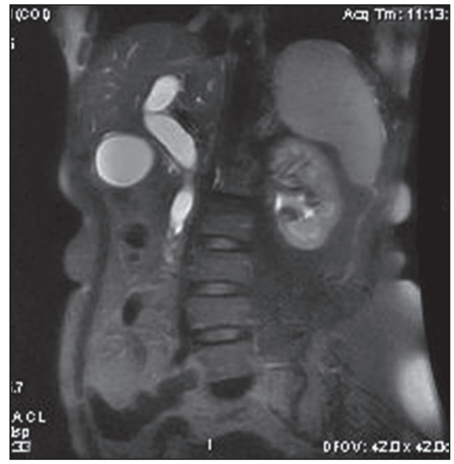

Figure 2: Thin slab magnetic resonance cholangiopancreatography showing a stricture in terminal common bile duct

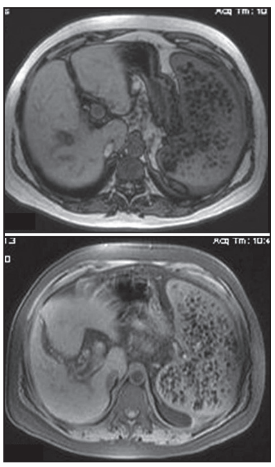

Figure 3: Fast spoiled gradient recalled echo images showing dilated portal vein with splenomegaly and congestive nodules in spleen

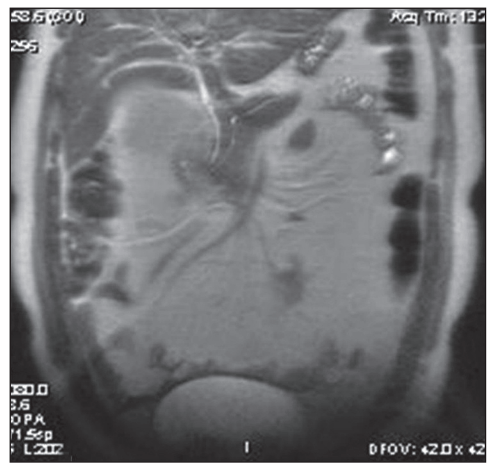

Figure 4: Coronal T2-weighted image showing compression of common bile duct by adrenal mass

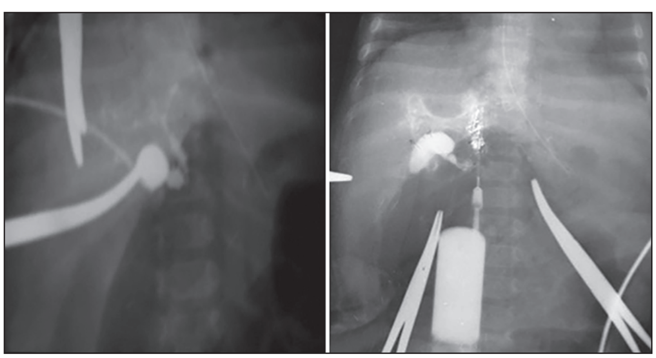

Figure 5: Intraoperative cholangiogram showing absence of part of biliary tract with no passage of contrast into duodenum with contrast pooling along intrahepatic biliary radical

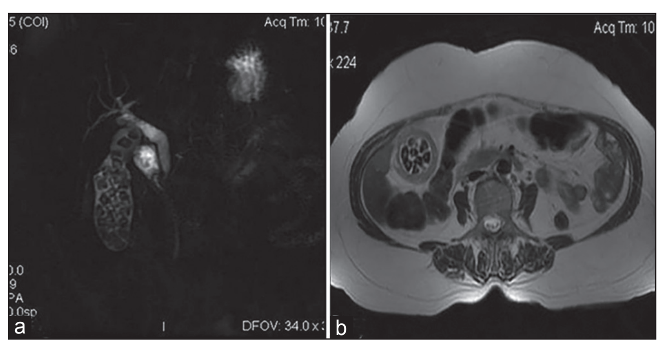

Figure 6: Magnetic resonance cholangiopancreatography image showing cholelithiasis (a) and axial T2-weighted image showing cholecystitis with cholelithiasis (b)

visualized at least in part in 48 of the 54 patients (89%). The pancreatic duct was well visualized in 31 patients (56%). The pancreatic duct was partially/just visualized in 18 patients (33%). The pancreatic duct was dilated in eight patients (15%). The pancreatic duct was not visualized in five patients (11%).

Final diagnosis

The final diagnosis was reached by direct cholangiography/surgery/histopathology. Choledocholithiasis was diagnosed in 10 patients, of which it was identified as the cause of obstruction in nine patients. Stricture was diagnosed as the cause of obstruction in 36 patients, of which 20 were

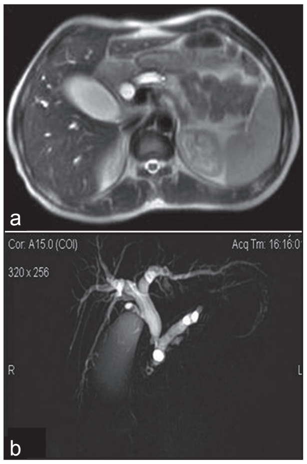

Figure 7: T2-weighted image showing double duct sign due to periampullary carcinoma (dilated common bile duct and pancreatic duct) (a) and magnetic resonance cholangiopancreatography image confirming it (b)

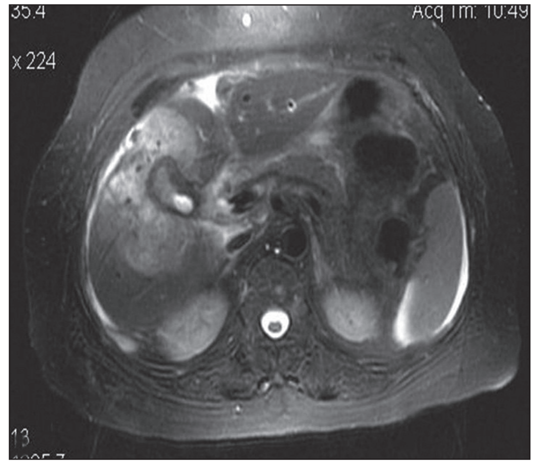

Figure 8: T2-weighted axial image showing gall bladder mass infiltrating into the liver parenchyma

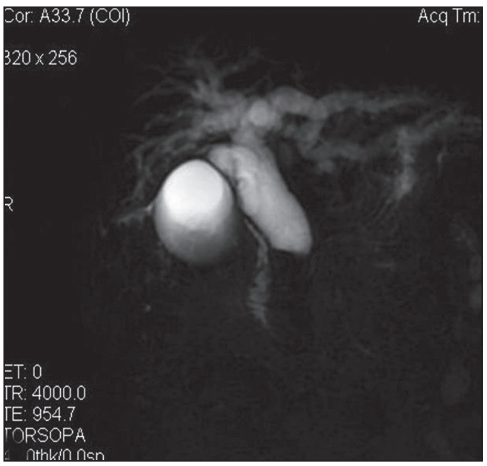

Figure 9: Magnetic resonance cholangiopancreatography image showing abrupt tapering of lumen of common bile duct — malignant stricture

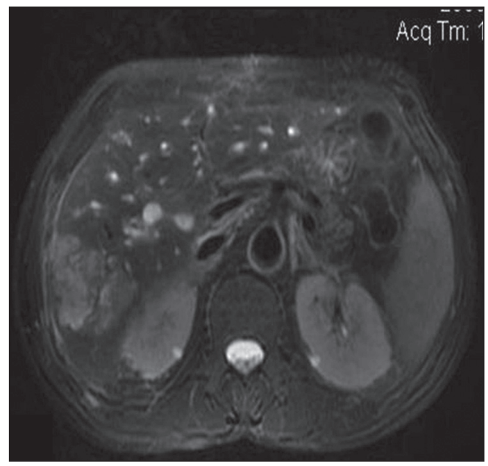

Figure 10: T2-weighted image of gall bladder mass showing metastasis in right lobe of liver

diagnosed as malignant and 16 were diagnosed as benign strictures. External compression was diagnosed as the cause of biliary obstruction in five patients. No obstruction was found in four patients.

Comparison of magnetic resonance cholangiopancreatography findings and final diagnosis

In 52 of the 54 patients, MRCP concurred with final diagnosis in identifying the level of block. MRCP correlated with final diagnosis in identifying the cause of obstruction in 48 of the 54 patients (89%). 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 96.29% (Pearson's correlation coefficient = 0.958, two-tailed test of significance ($P = 0.032$). Sensitivity of MRCP in identifying the cause of obstruction in comparison with final diagnosis was 92.30%. Diagnostic accuracy of MRCP in identifying the cause of obstruction in comparison with final diagnosis was 88% (Pearson's correlation coefficient = 0.949, two-tailed test of significance ($P = 0.017$). Sensitivity of MRCP in identifying choledocholithiasis was 91.66% and specificity was 90.46%. Diagnostic accuracy of MRCP in identifying choledocholithiasis was 88.75%. Positive predictive value of MRCP in identifying choledocholithiasis was found to be 73.33% and negative predictive value was 97.43%. Sensitivity of MRCP in identifying strictures was 100%. Specificity of MRCP in identifying strictures was 88.23%. Diagnostic accuracy of MRCP in identifying strictures was 94.87%. Positive predictive value of MRCP in identifying strictures was 94.87%. Negative predictive value of MRCP in identifying strictures was 94.87%.

DISCUSSION

The level of obstruction and the cause of obstruction were accurately depicted with MR cholangiography.[2]

Level of obstruction

The level of obstruction was in agreement with direct cholangiography in 52 of 54 cases with sensitivity of 100% and diagnostic accuracy of 96.29%. A higher accuracy of 100% for level of obstruction was reported using a breath-hold SS RARE sequence. The results obtained in our study were comparable to literature. However, there are two discrepancies, where false positive cases of distal CBD stricture was diagnosed on MRCP, but not seen on ERCP. Contraction of the choledochal sphincter might be misinterpreted as an impacted calculus or stricture in distal bile duct.[4]

In our study, hilar block was diagnosed in five cases (9.2%) by MRCP. These were confirmed by ERCP or surgery. Out of these, three were due to gall bladder carcinomas and one was due to Klatskin's tumor. MRCP has proved accurate for defining the extent of hilar and perihilar biliary ductal involvement.[5] 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.

Cause of obstruction

Majority of the cases of biliary obstruction are due to choledocholithiasis or strictures, either benign or malignant. 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.[6]

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.[7] Reported associated morbidity and death rates range between 9.8% and 13%, and 2.3% and 4%, respectively. Thus, to avoid sphincterotomy related complications, careful patient selection is needed before endoscopic retrograde cholangiography to prevent unnecessary sphincterotomies. 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%.[7] EUS can thus be an alternative to MRCP in the diagnosis of choledocholithiasis. However, this is an invasive technique requiring endoscopy and sedation.[8]

On MRCP calculi are identified as signal voids within the high signal intensity fluid in the bile ducts [Figure 1]. 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 9 patients out of 54 cases. In addition, six cases showed calculi in CBD in addition to the primary cause of obstruction. The size of the calculi ranged from 3 mm to 14 mm. The sensitivity, specificity and accuracy, for MRCP in the diagnosis of choledocholithiasis were 91.66%, 90.46%, and 88.75%, respectively. The positive predictive value and negative predictive values were 73.33% and 97.43%, respectively.

However, four false positive cases were identified, wherein stricture was the cause of biliary obstruction. Although stricture was correctly identified, calculi were reported as additional findings on MRCP. In two of these cases, malignant stricture of distal CBD with intraluminal mass was identified as cause of obstruction. In addition, multiple calculi were reported on MRCP in CBD. Operative diagnosis was of a benign biliary stricture with intraluminal sludge. Multiple filling defects seen on MRCP and interpreted as calculi and mass could be due to sludge. Another case was diagnosed on MRCP as postcholecystectomy mid-CBD benign stricture. Intraoperative diagnosis was cholangiocarcinoma, which was confirmed by surgery and histopathology. The intraluminal mass was misinterpreted as calculus. In another case, a benign biliary stricture due to chronic pancreatitis was diagnosed as associated with a calculus, which was not seen on ERCP. Hence, use of ERCP as a reference is not without limitations.

In our study, cholelithiasis was diagnosed in 18 patients [Figure 6a and b], which were also diagnosed on USG. All patients except two underwent cholecystectomy and surgically confirmed. Nevertheless, 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 [Figure 8].

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 tumors.[9] Complementary PTC may be needed to remedy this problem, but then the procedure related risks increase synergistically. Iodinated contrast material is particularly dangerous for deeply jaundiced patients with renal insufficiency. MRCP is able to satisfactorily delineate the dilated biliary system irrespective of the serum bilirubin level and renal function.

In our study, stricture was diagnosed by MRCP as the cause of obstruction in 42 of 54 patients. The final diagnosis included 19 benign [Figure 11a and b] and 20 malignant strictures [Figure 12a and b]. The strictures were diagnosed by MRCP with sensitivity, specificity and diagnostic accuracy of 100%, 88.23%, and 94.87%, respectively. The positive and negative predictive values were 94.87% and 94.87%, respectively. The reported sensitivity of MRCP for biliary strictures ranges from 78% to 100%.[9,10] The sensitivity and specificity of MRCP for diagnosing malignant strictures was 85% and 71%, respectively. Comparable results were obtained in our study.

Magnetic resonance cholangiopancreatography resulted in two false positive strictures in the distal CBD with proximal dilatation. ERCP findings confirmed the dilatation, but there was no distal bile duct stricture. Sixteen out of 19 benign biliary strictures were diagnosed correctly by MRCP. Two of these were false positive (discussed above) and another was false negative (discussed below). 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%. However, the diagnostic accuracy of strictures of intrahepatic bile ducts is still under investigation.

Cholangiocarcinoma usually presents as a stricture. Although morphological features of benign and malignant strictures are defined, differentiation may be difficult at times. In our study, a postcholecystectomy mid-CBD stricture was diagnosed as benign stricture as there was no obvious mass lesion or irregularity to suggest malignancy. This was diagnosed as Cholangiocarcinoma intraoperatively and histopathologically. In another case, a bile duct stricture with intraluminal mass was interpreted as cholangiocarcinoma on MRCP. The patient was operated and preoperative diagnosis was benign biliary stricture. Gall bladder carcinoma is an important cause of perihilar biliary obstruction. A correct diagnosis of gall bladder carcinoma was made in five out of five cases.[11] Nine cases of gall bladder carcinoma underwent MRCP in our study. In all cases MRCP was able to identify the level and cause of obstruction.

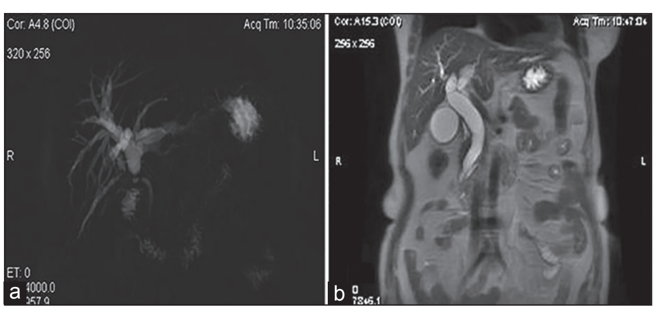

Figure 11: Magnetic resonance cholangiopancreatography image showing postcholecystectomy mid-common bile duct (CBD) benign stricture (a) and coronal T2-weighted image showing benign biliary stricture at terminal CBD (b)

In our study, all cases of periampullary carcinoma were diagnosed correctly. These could be distinguished correctly from CBD calculus due to the characteristic shape of obstruction [Figure 7a and b]. ERCP has an advantage over MRCP as it allows direct visualization of this area. Nevertheless, MRCP is as effective as ERCP for the detection of pancreatic carcinoma. However, T1-weighted gradient echo sequence acquired immediately following gadolinium administration is the most consistent technique to demonstrate pancreatic carcinoma.

The pancreatic duct was visualized at least in part in 48 of the 54 patients (89%). In two of the cases, there was beaded, irregular pancreatic duct with a calculus in it. In six of the cases both bile duct and pancreatic duct were dilated due to periampullary carcinoma [Figure 7a and b]. The abnormalities of pancreatic duct could be dilatation, narrowing, stricture or irregularity. The reported sensitivity for dilatation is 100%, 75% for narrowing, and 100% for ductal calculi. Thus, MRCP is useful for noninvasive imaging of the pancreatic duct.

The demonstration of anatomic variants is also important. MRCP could accurately demonstrate variants such as low cystic duct insertions, a medial cystic duct insertion, a parallel course of cystic and hepatic ducts with an accuracy of 95% and aberrant right hepatic ducts with an accuracy of 98%. In our study, right posterior duct was seen to join left hepatic duct in one case. Trifurcation at confluence was also seen in one case. Low insertion of cystic duct was seen in one case [Figure 13].

Limitations of magnetic resonance cholangiopancreatography

The limitations of MRCP are low spatial resolution with difficulty in differentiating between benign and malignant strictures in absence of mass.[4] Overlapping of the biliary system by fluid in gastrointestinal system [Figure 14] can be

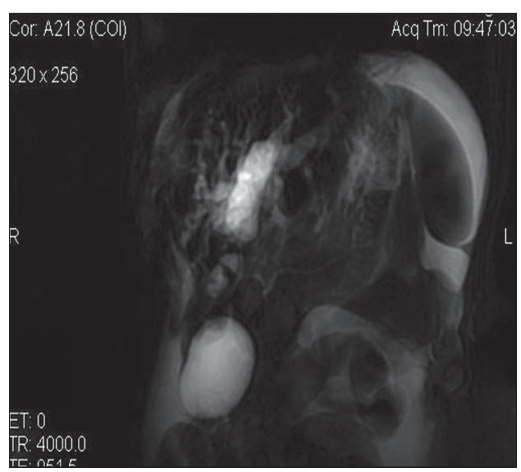

Figure 12: Magnetic resonance cholangiopancreatography image showing malignant stricture at hilum with ascites

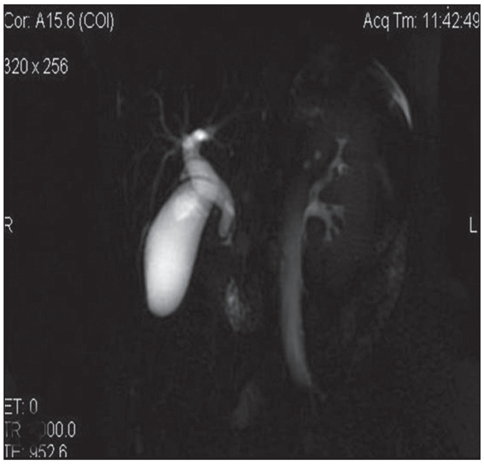

Figure 13: Magnetic resonance cholangiopancreatography image showing low insertion of cystic duct

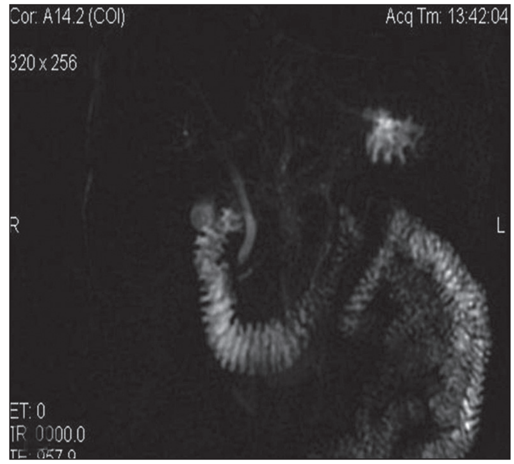

Figure 14: Magnetic resonance cholangiopancreatography image showing fluid in small bowel with consequent poor image quality

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 like calculus. Contraction of the choledochal sphincter may be misinterpreted as impacted calculus or stricture in the distal bile duct. Hence, if a filling defect or stricture is suspected in the periampullary region, repeat MRCP should be performed.[4] 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. However, 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.

CONCLUSION

MR cholangiography is a safe modality without the use of ionizing radiation and iodinated contrast agents. It has the ability to display the biliary tree and pancreatic duct by combining the advantages of projectional and cross-sectional imaging. The axial SSFSE and FSPGR images were essential in the diagnosis of extraductal pathology, useful in the confirmation of intraductal pathology and for staging of malignancies. 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.

Magnetic resonance cholangiopancreatography was comparable with direct cholangiography in identifying the level and cause of block in most of the patients. It is highly sensitive (100%) and diagnostic accuracy (96.29%) in identifying the level of block. The limitations of MRCP are low spatial resolution with difficulty in differentiating between benign and malignant strictures in absence of mass. MRCP is not only comparable with direct cholangiography in its diagnostic ability, but it has the tremendous advantage of being noninvasive.

Magnetic resonance cholangiopancreatography should be considered the investigation of choice in all cases of obstructive biliopathy unless some interventional procedure is/are indicated.

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