Limitation of Magnetic Resonance Cholangiopancreatography in
The Evaluation of Biliary Tree Pathology

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Abstract

Objective: Many pitfalls have been encountered in evaluation of Magnetic Resonance Cholangiopancreatography (MRCP) images that alter its diagnostic accuracy, the awareness of these pitfalls help in avoiding misinterpretation of images.

Patients and Methods: From the 234 patients, this retrospective study including 24 patients with false MRCP diagnosis compared with Endoscopic Retrograde Cholangiopancreatography ERCP, MRCP examinations were performed using a multi section turbo spin-echo sequence. The data obtained from Maximum Intensity Projection (MIP) image was correlated with the source image and other MRI sequences.

Results: Overall sensitivity, specificity, positive, negative predictive values and accuracy of MRCP in detecting biliary obstruction compared with ERCP measured 93%, 87%, 92% and 89% and 90% respectively. From the 234 patients, there are 24 (9%) misdiagnosed cases by MRCP as false positive n=17 (71%) and false negative n=7 (29%) cases. According to underlying cause of misdiagnosis those related to extraductal factor was accounted for most of recorded pitfalls resulting in 9 (37%) cases, followed by the technical factors 7 (29%) cases, anatomical variants that simulates pathology 6 cases (25%) and factors related to intraductal cause in 2 (8%) cases.

Conclusion: MRCP was accurate non invasive technique for evaluation of biliary pathology with diagnostic accuracy comparable to ERCP, the understanding of causes resulting in misinterpretation help in increasing its accuracy.

Key Words: MRCP – Biliary tree pathology.

Introduction

MAGNETIC Resonance Cholangiopancreatography (MRCP) continues to have a fundamental role in the non-invasive investigation of pancreatic and biliary disorders [1].

Multiple studies have documented the accuracy of MRCP in evaluation of biliary tree and main pancreatic duct pathologies, the diagnostic performance of MRCP is comparable to percutaneous cholangiography and Endoscopic Retrograde Cholangiopancreatography (ERCP) without the risks associated with these procedures, moreover, there is no use of ionizing radiation or iodinated contrast media [2-4].

However, despite the established role in the diagnostic pathway of patient with pancreatic and biliary disorders, MRCP has several limitation as well as pitfalls which may simulate or mask various pathologic conditions of the extrahepatic bile duct or main pancreatic duct [1,5,6].

Many pitfalls had been encountered in the MRCP evaluation of biliary and pancreatic pathology, including reconstruction artifacts, limitations of MRI pulse sequences, incomplete imaging of the pancreatobiliary tract, static imaging, limited spatial resolution, susceptibility artifacts, normal anatomical variants simulating disease, misinterpretation related to bile duct stones, non pathologic stricture due to pulsation from related vessels, pitfalls related to the cystic duct and periampullary region [7,9].

In 1980s, Endoscopic Retrograde Cholangiopancreatography (ERCP) followed by sphincterotomy has become the most widely used method for imaging and treating CBD stones [8,11], but recently and in large series ERCP had carried some morbidity (5 to 9.8%) and mortality rate (0.3 to 2.3%), due to pancreatitis, duodenal perforation and bleeding procedures [8,13,17]. Consequently improved diagnosis of biliary disease can be achieved with a knowledge of the benefits and limitations of MRCP [8,14,17].
The purpose of this study is to call attention to different diagnostic pitfalls the reader needs to be aware of on reporting MRCP images and the troubleshooting methods to overcome this pitfalls.

**Patients and Methods**

We retrospectively reviewed MRCP examination done during the period between December 2010 and February 2015; after obtaining an informed consent, only patients with false MRCP diagnosis in regarding to the gold diagnostic tool (ERCP) were included. From a total of 234 patients had MRCP during the study 200 patients with correct MRCP results were excluded, another 10 patients were further re-excluded due to lack of post MRCP confirmatory study. The final included group was 24 patients (15 male and 9 female, their age ranged between 25-80 years with mean age of 52.5±4).

All of the included patients had undergone ERCP as confirmatory study.

**MRCP examination:**

The patients were fasting for at least 4 hours before examination, pineapple juice was given (20 patients) as negative contrast agent to suppress the fluid signal from the gastrointestinal tract.

MRCP examination was performed using a 1.5-T MR imaging unit (Gyroscan NT; Philips Medical Systems), using a half Fourier multi section turbo spin-echo sequence with a 20-cm circular surface coil to obtain a high signal-to-noise ratio and high spatial resolution. With the following imaging parameters: Repetition time, 9,000msec; echo time, 288msec; echo train length, 32; section thickness, 3mm; intersection gap, none; field of view, 3240cm; and matrix, 256 x 128. Two sets of coronal images were obtained for MRCP; one without fat suppression while the other was obtained with fat suppression using a spectral presaturation with inversion recovery pulse. Images were acquired in the coronal plane during a 36-second inspiratory breath hold in co-operative patients. In unco-operative patients multisection sequences (approximately 18) 2.6sec each were performed. The coronal images obtained with fat suppression while the other was obtained with fat suppression using a spectral presaturation with inversion recovery pulse. Images were acquired in the coronal plane during a 36-second inspiratory breath hold in co-operative patients. In unco-operative patients multisection sequences (approximately 18) 2.6sec each were performed. The coronal images obtained with fat suppression were compressed into composite MRCP images by using a MIP algorithm. Oblique MRCP images were reconstructed at 15° intervals from the frontal to lateral view. The coronal images obtained without fat suppression were used as reference images for interpretation of the MIP reconstructed MRCP images.

**ERCP examination:**

ERCP were done using fluoroscopy (OEC Diasonics 9400) in the endoscopy suite under moderate sedation (principally intravenous midazolam and meperidine). If choledocholithiasis was detected or suspected at the time of ERCP, a sphincterotomy was undertaken so that gallstones could be extracted using a balloon catheter or retrieval basket.

**Data analysis:**

First, all MRCP studies (234 cases) were reviewed by three radiologists to select the included cases according to ERCP results, the selected cases (24 cases) were re-evaluated by three independent radiologists, 10 years of MR experience, unaware about the clinical history of the patients or the results of ERCP on separate session, hard films were reviewed for earlier patients and picture archiving and communication system images for more new series, including the coronal images obtained with and without fat suppression, MRCP source image and MIP reconstructed images.

They asked to make comment on Gall Bladder (GB), Common Bile Duct (CBD) and pancreatic duct for dilatation, stone, obstruction and its site, or the presence any criterion suggesting pseudo-obstruction.

We used criteria for diagnosis of pseudo-obstruction previously described in literature [9] including: (A) A focal stenosis or obstruction of the extrahepatic duct seen on MIP reconstructed MRCP images, (B) Minimal or no dilatation of the upstream biliary tree relative to the lower biliary tree, and (C) A vascular structure seen traversing the extrahepatic duct at the site of the focal stenosis or obstruction on the coronal source images obtained without fat suppression.

Factor resulting in misdiagnosis were divided into technical factors, extraductal causes, intraductal causes including those related to stone in the biliary tree and anatomical variants simulating diseases.

**Statistical analysis:**

The results were analyzed using SPSS 20 (SPSS for windows, Inc., Chicago IL), data was expressed in mean ± SD, and the accuracy, sensitivity, specificity, positive and negative predictive value for MRCP in comparing to ERCP was measured.

**Results**

MRCP had correctly diagnosed 200 (85.5%) cases with ERCP and surgically proved, 124 (62%) cases were true positive and 76 (38%) were true
negative, the pathology was bile duct calculi 58 (46.8%), bile duct stricture 18 (14.5%), hepatocellular tumor 16 (12.9%), pancreatic carcinoma 13 (10.5%), chronic pancreatitis 10 (0.8%), cholangiocarcinoma 6 (0.5%), ampullary carcinoma 3 (0.2%).

The overall sensitivity, specificity, positive, negative predictive values and accuracy of MRCP compared to ERCP as a gold standard in detecting biliary obstruction measured 93%, 87%, 92% and 89% and 90% respectively. The remaining 24 (9%) misdiagnosed cases by MRCP as False positive n=17 (71%) and false negative n=7 (29%) cases.

According to the cause of misinterpretation, those related to extraductal factors was account for most of recorded pitfalls and resulting in 9 (38%) false positive cases, followed by the technical factors 7 (29%) 5 false negative cases and 2 false positive cases, anatomical variants that simulates pathology was presented in 6 (25%) false positive cases and factors related to intraductal cause in 2 (8%) false negative cases.

Vascular pulsation artifacts resulted in extraductal pseudo-obstruction in 3 cases seen as linear indentation in the biliary tree (right hepatic duct 2 cases and common bile duct 1 case) Figs. (1,2) the correct diagnosis was seen in T2 WI without fat suppression as signal void structure related to site of obstruction and in one case CT with contrast shows the enhanced vessel at site of pseudo-obstruction.

Metallic foreign body artifact occur in two cases with previous history of cholecystectomy, affecting the right hepatic duct and site of anastomosis between both hepatic ducts and common bile duct at porta-hepatis (one case each) and seen as area of signal loss that diagnosed as stricture and correct diagnosis seen in axial and coronal T2 WI.

Other causes of extraductal pseudo-obstruction encountered was collection at site of previous cholecystectomy two cases Fig. (3), gas in the duodenum one case, and ascites one case, all resulting in false positive diagnosis of stricture.

Technical factor presented as false negative diagnosis due to MIP reconstruction artifact in cases with thick slap reconstruction resulting in misdiagnosis of 4 cases, missed bile duct stone 2 cases Figs. (3,4), missed ampullary mass 1 case Fig. (5) and miss diagnosis of stricture in one case, fluid in the stomach and duodenum overlap the biliary system with lack of visualization and difficult interpretation (2 cases) Fig. (6) and respiratory motion artifact presented as interrupted duct in one case.

Anatomical variants mistaken for pathology occur as a result of contraction of choledochal sphincter mistaken for distal CBD stricture in two cases Fig. (8), indentation by site of cystic duct insertion at CBD mistaken for filling defect two cases Fig. (9), bulging duodenal papilla one case and long cystic duct in one case diagnosed as dilated duct seen correctly on coronal T2 WI Fig. (10).

Fig. (1): A 63 year-old man with pseudo-obstruction due to vascular pulsation by the right hepatic artery (A) Multisection MRCP shows obstruction of the CBD with no upstream dilatation noted in biliary system. (B) Coronal T2 WI shows close anatomic relation of the common hepatic artery (white arrow) and the CBD. (C) Coronal multiplanner reformatted CT with contrast shows the enhanced right hepatic artery (white arrow) traversing the CBD.
Fig. (2): A 43-year-old woman with pseudo-obstruction due to vascular pulsation by the right hepatic artery (A & B) MIP and multisection MRCP shows two false obstruction of the biliary system one at the proximal CBD (white arrow) with no upstream dilatation noted in biliary system (C) Coronal T2 WI shows close anatomic relation of the common hepatic artery (white arrow) to site of false obstruction.

Fig. (3): A 66-year-old man with false obstruction due to post cholecystectomy fluid collection with missed distal bile duct stone at MIP reconstruction (A) Non visualization of part of the CHD and proximal CBD due to fluid overlapping (white arrow), no stones seen in distal CBD. (B) Coronal T2 WI shows small stone at distal CBD (white arrow). No other areas of stenosis seen at the CHD or proximal CBD confirmed by ERCP.

Fig. (4): A 57 year-old man with missed stone at distal CBD due to MIP reconstruction (A) MIP MRCP thick slap shows minimally dilated biliary tree, no stones could be detected (B & C) Coronal and axial T2 WI shows stone at distal CBD (white arrows).
Fig. (5): A 48 year-old women with missed ampullary mass due to MIP reconstruction (A) MIP MRCP thick slap shows markedly dilated CBD with abrupt cut off, no mass could be detected but presence of double duct sign give a suspicion of ampullary mass versus impacted stone at ampulla of Vater (B) Coronal T2 WI shows ampullary mass confirmed by ERCP (white arrows).

Fig. (6): A 57-year-old woman with non visualization of CBD due to fluid in duodenum and stomach (technical factor with lack of patient preparation) (A) non visualization of part of CBD due to fluid overlapping in duodenum (white arrow). (B) Coronal and axial T2 WI shows normal biliary tree, no dilatation.

Fig. (7): A 51 year-old man with missed stone impacted at ampulla of Vater in MIP reconstruction (A) MIP MRCP thick slap shows dilated biliary tree, no stones could be detected (B) Coronal T2 WI shows stone impacted at ampulla of vater (white arrow).
Fig. (8): A 69 year-old man with wrong diagnosis of distal CBD stricture due to sphincter of Oddi contraction (normal variants simulating pathology). (A) MIP MRCP shows stricture at the distal part of the CBD (white arrow), (B) Coronal T2 WI shows normal distal CBD confirmed at ERCP (white arrow).

Fig. (9): A 38 year-old female with wrong diagnosis of filling defect in the CBD due to indentation at site of cystic duct insertion (normal variants simulating pathology). (A) MIP MRCP shows filling defect at the CBD (white arrow), (B) Coronal T2 WI shows no filling defect confirmed at ERCP.

Fig. (10): A 45-year-old man with wrong diagnosis of two distal bile duct stones due to prominent duodenal papilla (normal variants simulating pathology). (A) Multisection MRCP shows two stones at the distal part of the CBD (white arrow), (B) Coronal T2 WI shows single CBD stone, the other one confirmed as normal prominent duodenal papilla at ERCP (blue arrow).
Discussion

Magnetic Resonance Cholangiopancreatography (MRCP) is widely substitute diagnostic ERCP in the assessment of patients with biliary obstruction [10].

In the present study we recorded sensitivity, specificity, PPV and NPV of MRCP compared with ERCP was 93%, 87%, 92% and 89% and 90% Respectively, this met those described by many previous studies with overall sensitivity ranging from of 85-97%, specificity of 75-98%, positive predictive values of 83-89%, and negative predictive values of 82-98% [11-14].

Unfortunately, numerous related MRCP pitfalls may simulate or mask pancreato-biliary disease [15]. Accurate preoperative reporting of MRCP is essential for the surgeon to operate safely and effectively [16].

In the present study we tried to draw attention to some of MRCP pitfalls that affect the diagnostic accuracy and can be avoided simply by reviewing the source images, repeating MRCP examination or changes in MIP reconstruction as using thin slap instead of thick slap reconstruction.

Accordingly we encountered several MRCP limitations related to extraductal (38%), technical (29%), anatomic variants simulating pathology (25%) and intraductal factors (8%), and resulting in either false negative 7 (29%) cases or false positive 17 (71%) cases.

The extraductal causes was due to vascular Pulsation artifact 3 (34%) cases, susceptibility artifact from metallic clips in post cholecystectomy patients 2 (22%) cases, collection at site of previous cholecystectomy 2 (22%) case, ascites one (11%) case and gas in the duodenum one (11%) case, in consensus with this results Griffin et al., [8], Watanabe et al., [9] and Albert & Riemann [17], they described the same entities as causes of extraductal pseudo-obstruction of the biliary tree on MRCP examination.

Pulsatile vascular compression resulting in misdiagnosis of pseudo-obstruction in 3 (34%) cases involving the common hepatic (two cases) and common bile duct (one case) the correct diagnosis was reached on reviewing the coronal source image, coronal and axial non fat suppressed T2 WI and in one case contrast enhanced CT was used to detect the vascular relation, in accordance Watanabe et al., [18] in their study on 234 patients they recorded a 33 (14%) cases of pseudo-obstruc- tion from arterial pulsation artifact and they stated that to differentiate between arterial pulsation artifacts pseudo-obstruction and true stricture carful interpretation of the coronal and transverse T2-weighted images without fat saturation is required, also Iris et al., [18], described vascular compression artifact as an extraductal cause of biliary pseudo-obstruction and they reported that trouble-shooting method for this artifact including dynamic helical CT or 3D MRA with contrast, however a more convenient method is carful interpretation of the non-fat-suppressed coronal source image, but in both studies they found that the most common site of pseudo-obstruction was common hepatic duct followed by left hepatic, proximal common bile duct then the right hepatic duct.

Susceptibility artifact from metallic clips of previous operation leading to pseudo-obstruction in two cases, the artifact was detected by reevaluating axial and coronal fat suppressed T2 WI, many previous studies described metallic artifact to be a cause of pseudo-obstruction due to signal loss and they reported that careful inspection of coronal source image and axial T2 reveal that the signal void artifact were eccentric and away from the bile ducts [9,15,18,19].

Gas in the duodenum resulting in overlooking of bile duct stone (one patient), evaluation of the source image allow to get the correct diagnosis in those patients, this in agree with previous reports results [5,18,19].

Image artifacts can be produced by a bright signal arising from stationary fluid within the adjacent duodenum, duodenal diverticulae, and ascetic fluid [10,19], in this study also we found that ascetic fluid resulting in artifact overlapping the common bile duct and interfere with full evaluation of the duct which could be get over by reviewing the source image.

Other cause of extraductal pitfalls found in this study and not mentioned previously, the presence of fluid collection at the GB fossa as postoperative complication in one patient which overlapping the common bile duct with difficult evaluation of the duct, the trouble-shooting for this entities was the reviewing of axial T2 weighted image.

Limitations from technical factors occur as a result of MIP reconstruction artifact leading to missed stone (3 cases), missed ampullary mass in (1 case), and missed stricture in (1 case), the correct diagnosis was made by reviewing the source image, coronal and axial T2 WI or using thin slap instead of thick slap MIP, similar results was reported by
they stated that MIP reconstructed images completely obscure small filling defects due to the partial volume effect; therefore, evaluation should be based on the source images.

Fluid in stomach and duodenum resulting in misinterpretation of part of biliary tree overlapped by the fluid (two cases), this is in agree with previous studies [8,9,19].

Respiratory motion artifact was present in one patient in our study as interruption of the duct, this artifact has been described as cause of MRCP pitfalls in previous studies and resulting in stenosis, interruption, dilatation, or even duplication of the biliary tree [18,19].

We had two cases of impacted stone at the ampulla of vater in which the stone was missed and diagnosed as false negative by MRCP, in accordance with this Griffin et al., [8] they stated that impacted stone may be missed in MRCP due to lack of hyper intense bile surrounding the stone.

Anatomical variations of the extrahepatic biliary system are common [20,21,23]. Adequate knowledge of such variations and an appropriate roadmap before any surgical, endoscopic or percutaneous procedure/intervention is mandatory the reason is that the poor visualization of the surgical field may cause accidental bile duct injury, which is rare but potentially severe complication [20,22,23].

In this study anatomical variants simulating pathology occur as a result of contraction of sphincter of Oddi seen in two patients and bulging duodenal papilla in one case causing pseudo-obstruction in the distal common bile duct that was negative at ERCP, Watanabe et al., [9] had described contraction of sphincter of Oddi to be misinterpreted as impacted stone or stricture in the distal common bile duct and they stated that when a stricture or filling defect was seen in periampullary region, MRCP need to be repeated as choledochal sphincter contraction is transient.

Anomalies of cystic duct as long low inserted cystic duct was recorded in one patient that misdiagnosed as common bile duct dilatation also indentation on the bile duct at site of insertion of cystic duct was seen in one case as false filling defect, in accordance with this George et al., [21] in their study stated that when the cystic duct runs parallel to the common hepatic duct for some distance, the two structures together may be mistaken for a dilated common bile duct. This pitfall is most likely to occur on an MIP reconstructed image. Therefore, the source images should be evaluated carefully.

Our study had several limitation, first was the small number of included cases so the incidence of each pitfalls can not be accurately assessed, second in some cases thick slap MIP reconstruction was used leading to misdiagnosis of small stone, and the third was the study was retrospective so the patients could not be re-evaluated.

In conclusion:

Several diagnostic pitfalls are associated with MRCP mentioned in this study but they don't affect the diagnostic accuracy of MRCP as it account for low percentage and easily avoided by careful evaluation of the source image and good patients preparation.

References


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