Magnetic Resonance Cholangiopancreatography: Value of Using the Half-Fourier Acquisition Single-Shot Turbo Spin-Echo (HASTE) Sequence

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Abstract

The purpose of this study was to evaluate the accuracy of magnetic resonance cholangiopancreatography (MRCP) for visualisation and diagnosis of pancreatico-biliary diseases. Our results of 35 case studies, correlating with results from endoscopic, percutaneous cholangiopancreatography or laparotomy, showed that MRCP performed using the half-Fourier acquisition single-shot turbo spin echo (HASTE) sequences was fast and accurate for depiction of the biliary and pancreatic system, with a diagnostic value comparable to that of direct cholangiography. The presence of biliary obstruction was accurately diagnosed in all but one patient. In hilar strictures, MR cholangiogram was able to depict the intrahepatic biliary tree proximal to the level of obstruction which was not readily displayed by endoscopic retrograde cholangiopancreatography (ERCP) (Figs. 1 & 2). This overview of the entire biliary system was found to be advantageous forpreproceduralplanning. However, the accuracy for stone detection was limited by the presence of aerobilia from previous sphicterotomy or biliary-enteric anastomosis. Ductal stones less than 3 mm in size within a non-dilated system may be missed due to inadequate spatial resolution. This occurred in a patient with pancreatic duct stones. It is hoped that the accuracy of HASTE magnetic resonance cholangiopancreatography in evaluation of pancreatico-biliary disease would obviate the need for diagnostic invasive cholangiography in selected patients.

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Introduction

Direct cholangiopancreatography has long been considered the standard of reference for assessment of the biliary tree and is generally safe, reliable and widely available. However, these methods are operator dependant and have the potential for morbidity in some patients (3% to 5%)[1,2] with complications such as acute cholangitis, pancreatitis, haemorrhage and bowel perforation. In recent years, significant advances in the field of abdominal imaging have led to better image resolution and faster imaging times.[3-8] There have been many studies on the use of magnetic resonance cholangiopancreatography (MRCP) in the assessment of pancreatico-biliary disease. Comparison with direct cholangiography and operative findings has confirmed the accuracy of MRCP in diagnosis of biliary disease.[3-9] In our study, we aim to establish the diagnostic value and accuracy of this technique in our practice and identify patients who would benefit most from a non-invasive cholangiogram thereby lowering the number of purely diagnostic invasive cholangiograms in our institution, with their inherent morbidity.

The multi-slice technique offered by the half-Fourier acquisition single-shot turbo spin-echo sequence (HASTE) enables display of a cholangiographic image in the coronal plane by using three-dimensional post-processing techniques, thereby combining the benefits of cross-sectional and projectional techniques. With HASTE, all image information is acquired after a single excitation pulse. Using the half-Fourier method of reconstruction, data from as few as half the number of phase-encoding steps are used to generate the image. The reconstruction is based on the inherent symmetry of k-space along the phase axis. The advantage of this is the increased imaging speed. However, this is at the expense of decreased signal-noise ratio and increased risk of blurring.

Materials and Methods

A review of 35 patients using MRCP was performed for various pancreatico-biliary diseases diagnosed clinically, either by ultrasound or computed tomography (CT) scan. All patients were fasted for at least 4 hours prior to the study. All were scanned using a 1.5T Sie-

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mens (Erlangan, Germany) Magnetom Vision magnetic resonance scanner with a phased-array body coil. T1 FLASH (fast low-angle shot) and True FISP sequences were initially acquired to determine the orientation of the ducts. These were followed by a HASTE sequence. The parameters used for this sequence included repetition time ∞/95 msec, matrix 240 x 256, slice thickness 4 mm with no gap, field of view 270 x 270 mm, number of signals acquired, one; acquisition time, 16 to 18 seconds. Fat suppression and shim adjustments were used in all cases. Fluid containing structures like spinal canal, renal pelvis and bowel were eliminated by varying imaging orientation and sequential multi-slice techniques. Post-processing of the images using targeted maximum intensity projection (MIP) and multiplanar reformation of the data set allows for 3D projectional imaging to any arbitrary plane. Conventional MR imaging of the abdomen was conducted to evaluate the liver and pancreas in selected cases.

The images were reviewed by the same radiologist and results were correlated with the findings of direct cholangiography and/or operative findings. The MRCP images were evaluated for the presence, level and cause of obstruction. Standard cholangiographic criteria were used to differentiate malignant from benign strictures.

Results

Of the 35 patients scanned, there was an equal male to female ratio. Their ages ranged from 29 to 88 years, with 15 patients more than 70 years old. There were 25 cases with direct correlation with endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic cholangiography (PTC) or laparotomy (Table I). Five patients had normal MRCP findings and hence, no further investigation was performed. Four patients were diagnosed to have common bile duct (CBD) stones on MRCP but later failed ERCP. In 3 of these cases, the patients had had previous Bilroth II partial gastrectomy and the papilla could not be visualised during ERCP. One patient had advanced carcinoma of the colon with hilar metastases resulting in hilar stricture, but opted for palliative chemotherapy. Another had a prior right hepatectomy with isolation of the segment 4 intra-hepatic duct demonstrated on MRCP, but developed hepatic failure, and was treated conservatively.

The image quality was generally good. Visualisation of pancreatico-biliary anatomy in MRCP and ERCP/PTC is shown in Table II. The gallbladder, when present, was visualised in all instances. There were no significant susceptibility artefacts from surgical clips of patients who had previous cholecystectomy. The common bile duct and common hepatic ducts were visualised along their entire lengths. The intrahepatic ducts were depicted up to at least the 2nd level ducts, with two-thirds of cases depicting at least 3rd level ducts. The main pancreatic duct was identified in the head and body in 27/35 (77%) patients on the maximum intensity projection (MIP) images. However, it could be clearly visualised in the tail of the pancreas in the source images except for 1 patient who was extremely ill.

TABLE I: TYPES OF PANCREATICO-BILIARY DISEASES DETECTED WITH ERCP/PTC OR LAPAROTOMY CORRELATION

Type	Number
Strictures	12
Choledocholithiasis	8
Post-cholecystectomy state	1
Choledochal cyst	1
Pancreatic duct stones	1
Normal biliary tree	2

The level, nature and extent of biliary obstruction was accurately diagnosed in all our patients (Tables I & III). The diagnostic accuracy of MRCP and ERCP for various pancreatico-biliary diseases in this study is shown in Table IV. Of the 8 patients with choledocholithiasis, 7 had ERCP performed subsequently. The results correlated well with ERCP. In 1 patient, 3 small pancreatic stones (less than 3 mm in size), lodged in a non-dilated pancreatic duct, were not visualised during MRCP. These were subsequently removed during ERCP. However, no biliary calculi were detected by direct cholangiography when none were present on MRCP.

Ductal anatomy proximal to the level of obstruction was often not visualised in ERCP (Table I) in order to avoid bacteraemia with introduction of contrast/catheter into an obstructed system once this was diagnosed. The pancreatic duct was not opacified in some patients so as to avoid the risk of pancreatitis where the pancreatic duct and pancreas were demonstrated to be normal on CT scan. Complications encountered with ERCP included 4 patients with mild pancreatitis, and 1 with subclinical perforation of the afferent loop of bowel in a patient with previous Bilroth II partial gastrectomy.

There were no complications from MR cholangiograms in our study. None of the patients was claustrophobic. There were 2 patients who were unable to breath-hold adequately due to severe illness. Nonetheless, these less than optimal studies were able to yield sufficient diagnostic information so that the level of obstruction could be determined.

Periampullary pathology could not be confidently excluded in those with a dilated CBD down to the level of the ampulla.

Discussion

CT scan and ultrasound scan have been the commonest non-invasive modalities for evaluation of biliary

TABLEII: COMPARISON OF IMAGE QUALITY – VISUALISATION OF PANCREATICO-BILIARY SYSTEM IN MRCP AND ERCP/PTC

Structures visualised	MRCP (n = 35)	ERCP/PTC (n = 19)
2nd order intrahepatic duct branches	12/35	6/19
3rd order intrahepatic duct branches	23/35	10/19
Common hepatic duct	35/35	18/19
Common bile duct	35/35	19/19
Cystic duct	13/35	9/19
Main pancreatic duct	27/35	10/19

TABLE III: TYPES OF STRICTURES

Type	Number
Benign periampullary stricture	2
Postoperative stricture	3
Malignant stricture	7
Pancreatic carcinoma	2
Metastatic hilar lymphadenopathy	1
Klatskin tumour	3
Hepatocellular carcinoma with intraductal invasion	1

obstruction. Whilst these methods are relatively sensitive for the detection of obstruction, direct cholangiography remains the gold standard for visualizing the biliary and pancreatic ducts and for defining the cause of obstruction. However, direct cholangiography is both operator dependent and invasive, and is not without risks and complications.[1,2]

Several MR techniques have been used in the past, including two-dimensional breath-hold gradient echo and fast spin-echo sequences, as well as a respiratory-triggered, three-dimensional, fast spin-echo technique. More recently, a half-Fourier acquisition single-shot turbo spin-echo (HASTE or half-Fourier RARE) has been developed and shown to be more accurate than earlier imaging techniques, with results comparable to direct cholangiography.

In our study, using the HASTE technique, we were able to clearly image the biliary tree and pancreatic duct in almost all cases. In our experience, imaging room time for MRCP alone was approximately 20 minutes. Respiratory artifacts were greatly reduced in these breath-hold scans, except in some instances when extremely ill patients could not breath-hold for 16 to 20 seconds. Susceptibility artifacts from bowel gas and foreign bodies like metallic surgical clips or stents, were negligible due to the narrow temporal spacing of the radio-frequency refocusing pulses. In this study, MRCP used in conjunction with MR imaging of the liver and pancreas allowed depiction of the tumour causing ductal obstruction and in some cases, helped to determine resectability of the lesion.

TABLE IV: COMPARISON OF DIAGNOSTIC ACCURACY OF MRCP VERSUS ERCP/PTC IN DETERMINING THE NATURE OF OBSTRUCTION IN VARIOUS PANCREATICO-BILIARY DISEASES

Type of obstruction	MRCP	ERCP/PTC
Klatskin tumour	3/3	3/3
Metastatic hilar lymphadenopathy	1/1	0
Hepatocellular carcinoma with intraductal invasion	1/1	1/1
Pancreatic carcinoma	2/2	2/2
Choledocholithiasis	8/8	7/7
Pancreatic duct stone	0/1	1/1
Postoperative stricture	3/3	1/2
Benign periampullary stricture	112	2/2

MRCP offers the important advantage of being able to delineate the biliary tree non-invasively in malignant obstruction. As a result, there can be no introduction of sepsis secondary to instrumentation and injection or over injection of an obstructed biliary system. Visualisation of surgically altered biliary anatomy and the proxi-

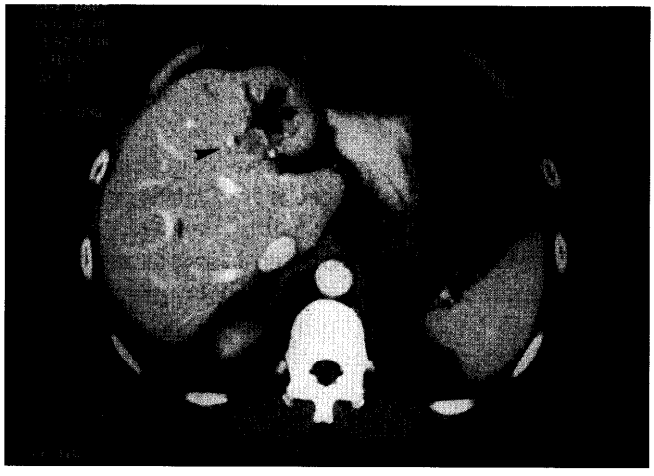

Fig. la. Patient presenting with fever and jaundice. CT scan showing selective left intrahepatic ductal dilatation with a filling defect within the duct.

Fig. lb. MRCP showing a signal void representing a ductal stone within the left intrahepatic duct with proximal dilatation of its branches.

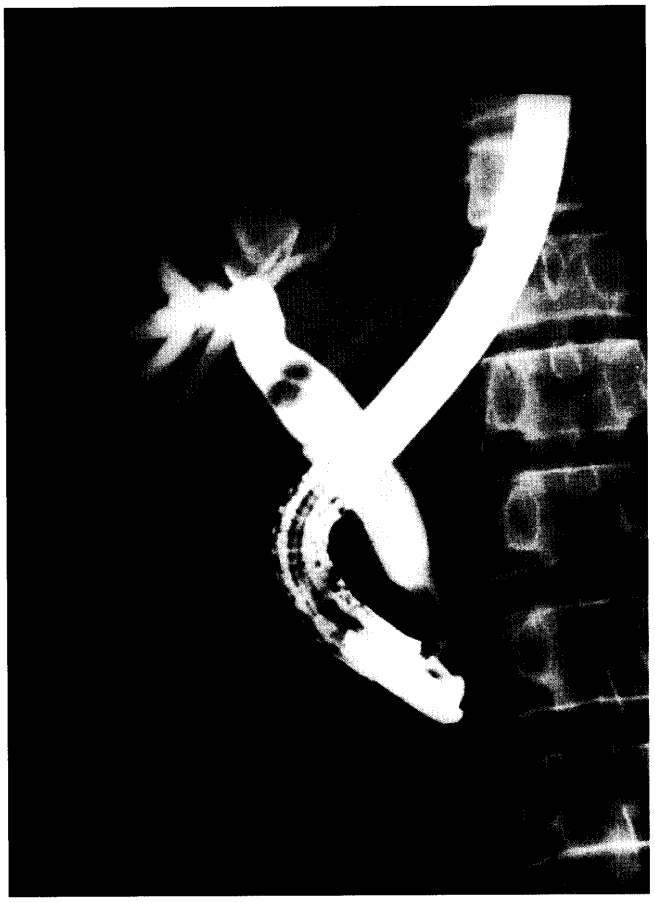

Fig. 1c. ERCP performed confirmed the presence of the stone which had to be removed surgically.

Fig. 2. A 44-year-old man presented with obstructive jaundice. MRCP showing a Type IV cholangiocarcinoma with dilatation of the intrahepatic ducts. The proximal extent of obstruction is clearly visualised, an obvious advantage of MRCP in assessment of biliary strictures.

mal extent of high level obstructions are often limited in direct cholangiography, but are clearly depicted with MRCP as shown on Figures 1 to 4.

There were 4 cases of postoperative strictures, 2 of which were due to postoperative isolation. These were suspected on the CT scans. For such cases, until the

Fig. 3. A 36-year-old woman with previous cholecystectomy and recurrent postoperative cholangitis. Ultrasound and CT scan showed segmental dilatation of intrahepatic ducts in segments 6 and 7 of the liver. ERCP performed was unable to delineate the obstructed segment. MRCP showing clearly the stricture caused by inadvertent isolation of the ducts during previous surgery as well as the extent of the obstructed ductal system.

Fig. 4. Patient with previous choledochojejunostomy presented with recurrent episodes of acute cholangitis. MRCP confirmed the presence of a stricture at the anastomotic site and proximal intrahepatic ductal dilatation which was confirmed during surgery.

advent of MRCP, only percutaneous cholangiography could confirm and delineate the obstructed segment. There were 2 biliary-enteric anastomoses with strictures which were confirmed on MRCP. MRCP established the

diagnosis in 4 cases of choledocholithiasis, which went on directly to surgery. Previous Bilroth II surgery had been performed in 3 of these patients, making ERCP technically difficult.

The MRCP technique has several limitations. The most obvious is the inability to provide therapeutic drainage and stenting procedures, unlike endoscopic and percutaneous cholangiography. It is also limited by the presence of ascites and moderate fluid collections in the upper abdomen that may obscure ductal anatomy on the maximum-intensity projection images. However, workstation 3D software postprocessing can often remove such excess fluid. Aerobila and haemobilia produce filling defects that may simulate ductal stones. Misdiagnosis of a stricture may be made in the presence of large amount of aerobilia due to signal voids created in the region of the anastomosis. The accuracy of detecting minor degrees of ductal dilatation and small biliary calculi less than 3 mm size in non-dilated ducts is uncertain due to the low spatial resolution compared to direct cholangiography. This may to some extent be reduced by reviewing source images and using targeted small-volume maximum-intensity projection as suggested by Barish et al.[5] Periampullary pathology is often difficult to interpret if the bile duct is dilated down to the ampulla, in the absence of an associated tumour mass within the pancreas. Other limitations are similar to those for MR imaging of the abdomen in general, that is, patient motion, peristalsis, claustrophobia, metallic implants and pacemaker devices.

Cholangiocarcinomas complicating diseases like primary sclerosing cholangitis and Caroli's disease are currently best demonstrated by a combination of CT scan and direct cholangiography. The role of MR cholangiography in this area has yet to be established. However, MRCP has been found to be valuable in the demonstration of cholangiocarcinoma complicating primary sclerosing cholangitis when the results of CT scan and other modalities were equivocal or unavailable.[10]

In conclusion, HASTE MR cholangiography is a fast, non-invasive technique, capable of rapidly providing diagnostic information about biliary anatomy which is equivalent to invasive direct cholangiography in a large percentage of patients. It is, therefore, highly recommended where invasive techniques are incomplete, unsuccessful or technically difficult. It is a useful preprocedural/preoperative assessment of the biliary tree in patients with segmental intrahepatic ductal dilatation from malignant or benign strictures, in particular strictures at or above the hilum, and enables non-invasive stratification of patients for treatment of malignant obstruction. Therapeutic ERCP or PTC can then be reserved for those patients who may benefit from preoperative drainage or for those deemed inoperable. This may obviate the need for invasive diagnostic cholangiography and its attendant risks in selected cases. For patients with obstructive jaundice from choledocholithiasis or for periampullary pathology, ERCP is still preferred as it can be therapeutic as well as provide direct visualisation of the papilla.

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