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## COMPARISON OF BREATH HOLD MULTI-SLICE HASTE MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY WITH ENDOSCOPIC CHOLANGIOPANCREATOGRAPHY: INITIAL EXPERIENCE

Kumar G, Abdullah BJJ, Rosmawati<sup>1</sup>, Goh KL<sup>1</sup>, Moosa F, Ahmad Sarji S & Bux SI

### ABSTRACT

**OBJECTIVE :** To compare in a prospective and double blinded fashion the accuracy of a new breath-hold multi-slice half Fourier acquisition single shot turbo spin-echo technique (HASTE) magnetic resonance cholangiopancreatography (BHASTE MRCP) against endoscopic retrograde cholangiopancreatography (ERCP) in the diagnosis of patients presenting with biliary and pancreatic pathology.

**PATIENTS AND METHODS :** A total of 20 patients had both breath-hold thin slice MRCP and ERCP. There was no preparation of these patients prior to the breath-hold multi-slice MRCP. The acquisition times for MRCP was 20 seconds. For the MRCP, both the source images and MIP images were evaluated. The results were reported independently by two radiologists. The presence of dilatation, stricture and intraductal abnormalities were recorded. The ERCP was used as the gold standard.

**RESULTS :** MRCP and ERCP finding concurred in all but one patient in whom ERCP failed. An accuracy of 100% (with a sensitivity and specificity of 100%). MRCP was able to show more dilated intrahepatic ducts than ERCP. The presence of fluid in the upper gastrointestinal tract did not obscure any pathology. There were three patients with subcapsular fluid noted. This finding on MRCP has not been previously reported.

**CONCLUSION :** BHASTE MRCP is an excellent non-invasive technique to assess the biliary and pancreatic ducts and may be used to select those patients who require therapeutic ERCP. This may be done without the need for any oral preparation. This will reduce the cost as well as the complications. The additional ability to perform conventional axial MR images at the same sitting with not much extra scanning times makes this examination of choice as well as providing a "road map" for planning intervention. BHASTE MRCP has overcome some of the problems of respiration and volume averaging.

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Departments of Radiology and

<sup>1</sup> Medicine, University of Malaya Medical Center, Kuala Lumpur, Malaysia.

**Address correspondence: G Kumar**

Department of Radiology, University of Malaya Medical Center, Jalan Universiti, 50603, Kuala Lumpur, Malaysia.  
Tel. No. 03-7502069 Fax No. 603-7581973 Email gkumar@medicine.med.um.edu.my



## INTRODUCTION

Magnetic resonance cholangiopancreatography (MRCP) is a new imaging method to non-invasively visualise the biliary and pancreatic ducts (1-6). This method allows the generation of projectional images similar to those of endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic cholangiography (PTC). These images are obtained without the need for any kind of contrast medium (oral or intravenous) and depends on the visualisation of fluid within the ducts of the pancreas and liver. In addition this procedure can be carried out on an out-patient basis and therefore may be cost-effective. The role of MRCP has not been defined presently and the absence of any intervention makes it an appealing method to visualise the ducts. Numerous different sequences have been used to generate the MRCP images and we evaluated the accuracy of a new breath hold multi-slice Half Fourier turbo spin echo (HASTE) MRCP to ERCP in evaluating biliary and pancreatic duct pathology

## PATIENTS AND METHODS

A total of 20 patients (9 male and 11 female) with a mean age of 50 years (ranging from 15 to 80 years) who presented to the University of Malaya Medical Center with evidence of either biliary or pancreatic pathology were evaluated in this study. The patients were planned for MRCP prior to ERCP but this was not always possible due to the difficulty in getting access to the MRI scanner. Fourteen MRCP were performed on an average of 3 days (range of 1 to 9 days) prior to ERCP and another six were done on an average of 3 days (range 1-15 days) after ERCP.

The MR images were acquired on a 1.5T Magnetom Vision scanner (Siemens, Erlangen, Germany). A circular polarised array wrap around coil was used for this study. The patients were not prepared in any way prior to the MRCP. No

antiperistaltic agents were given either. An initial coronal and axial localiser images were acquired. From these images three sets of coronal oblique scans (13 each time) using the HASTE sequence were prescribed to cover the entire liver. HASTE techniques use a single slice selective excitation but multiple refocusing radiofrequency (RF) pulses. Each echo is acquired after the application of a different phase encoding gradient pulse. The scanning parameters used for the MRCP are as shown in Table 1. The patients were given instructions of the proper technique for breath holding. The source images from the HASTE sequences were evaluated both individually as well as reconstructed in three dimension (in the coronal plane) using a maximal intensity projection (MIP) algorithm. These three dimensional images were viewed at 15-30° around the cranio-caudal axis. Normal CBD calibre was assumed to be 4-5mm until 50 years with an increase of 1mm per decade thereafter (22).

The patients were admitted and sedated with antibiotic cover prior to ERCP. The ERCP was carried out by two senior endoscopist using a side viewing endoscope (Olympus, Tokyo, Japan). Both the biliary tree and pancreatic ducts were attempted to be demonstrated. Radiographs of the filled ducts were acquired under fluoroscopic visualisation. The examination was ended only when all the necessary data was obtained. The patients were kept in the ward overnight and discharged if there were no complications. The ERCP was considered as the gold standard. Conventional cholangiographic measurement were adjusted for magnification using the endoscope or catheters of known diameters as reference.

The images from the two studies were evaluated blindly by two radiologists independently (BJJA & GK) with the clinical



details provided. Studies where the two readers disagreed on the initial assessment were re-evaluated and agreement reached by consensus. The overall image quality of both studies was graded into three categories: Good, average and poor. Abnormalities of the biliary and pancreatic ducts (dilation, stricture, filling defects as well as other findings) were also evaluated.

## RESULTS

The results are summarised as shown in Tables 2 to 5

**Table 1** Scanning parameters for the breath hold haste sequence

Parameters	Values
TR	15msec
TE	6msec
Flip angle	300
Slice thickness	10 mm
Scan time	16 sec
Distance factor	0.0
Matrix	240x256
Field of view	270 mm
No. of acquisition	1
Fat saturation	Yes

**Table 2** The number of patients with dilated biliary ducts on MRCP and ERCP.

Location	Examination	
	MRCP	ERCP
Common bile duct	11	10
Common hepatic duct	14	13
Intrahepatic ducts	17	16
Cystic ducts	0	0

**Table 3** The number of patients with filling defects in the biliary system.

Location	Examination	
	MRCP	ERCP
Common bile duct	4	4
Common hepatic duct	0	0
Intrahepatic ducts	2	2
Cystic ducts	0	0
Gall bladder	3	1

**Table 4** Number of patients with strictures of the biliary tree

Location	Examination	
	MRCP	ERCP
Common bile duct	9	8
Common hepatic duct	3	3
Intrahepatic ducts	3	3
Cystic ducts	0	0

**Table 5** Number of patients with pancreatic duct pathology

Abnormality	Examination	
	MRCP	ERCP
Stricture	2	2
Dilatation	2	2
Filling defects	1	1

## A. IMAGE QUALITY

ERCP was of good quality in nineteen patients but had to be abandoned in one patient due to a duodenal perforation. MRCP had a similar result with good quality images in nineteen patients. In one patient the presence of breathing artefacts degraded the subsequent MIP images and therefore considered to be of poor diagnostic value. However evaluation of the source images of this patient were considered to be of average diagnostic value. None of the MRCP had to be abandoned.

## B. NORMAL BILE DUCTS

MRCP was able to identify all the normal ducts of the liver and pancreas without false positive or false negative.

## C. BILIARY DUCTAL DILATATION

MRCP was able to show a higher number of dilatations of the common bile and hepatic and intrahepatic ducts compared to ERCP. This was due to the failure of ERCP in one of the patients. In those patients where MRCP and ERCP concurred the level of obstruction was correctly identified by MRCP. In four patients the MRCP was able to show more intrahepatic ducts distal to a stricture compared to ERCP (Figure 1a, b). In addition MRCP was able to show a higher number of strictures in the common bile duct compared to ERCP because of the single ERCP failure. Otherwise MRCP and ERCP were similar.



**Fig. 1A.** ERCP demonstrating a abrupt narrowing (cholangiocarcinoma) (short arrow) involving the common hepatic duct. The proximal ducts are unopacified



**Fig. 1B.** MRCP demonstrating a tight stricture involving the common hepatic and adjacent right and left hepatic ducts (long thick arrow). Note the dilated proximal intrahepatic ducts (long thin arrow)

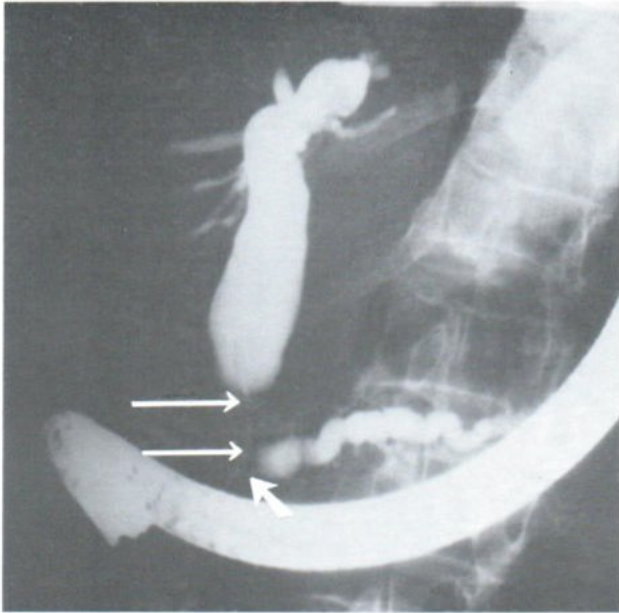
## D. SUBCAPSULAR FLUID

In three patients there was subcapsular fluid seen on MRCP prior to ERCP. Two of these patients had normal MRCP and ERCP studies while the third had dilated left intrahepatic ducts secondary to a cholangiocarcinoma infiltrating the liver. These patients did not have any heart failure or hypoproteinaemia.

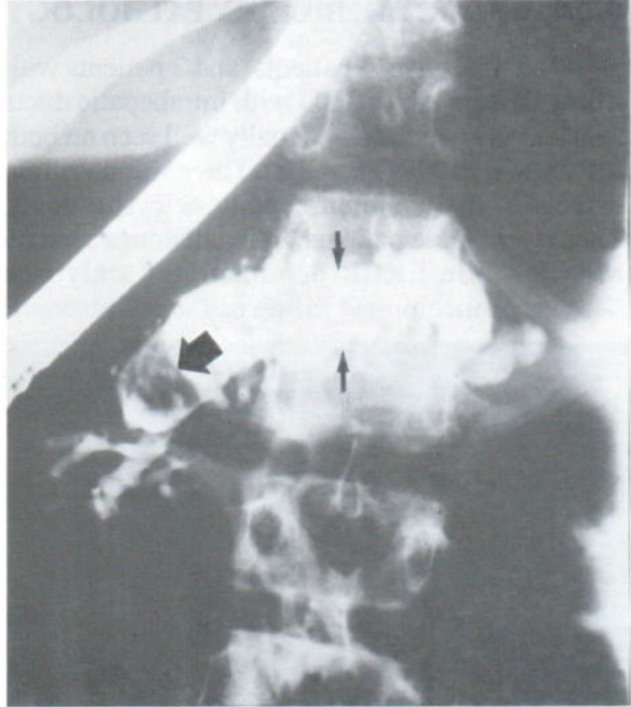
## E. BILIARY DUCTAL STRICTURES

The MRCP and ERCP findings concurred for both the number and location of strictures except for the single ERCP failure where a stricture in the CBD was not demonstrated (Fig. 2a,b).

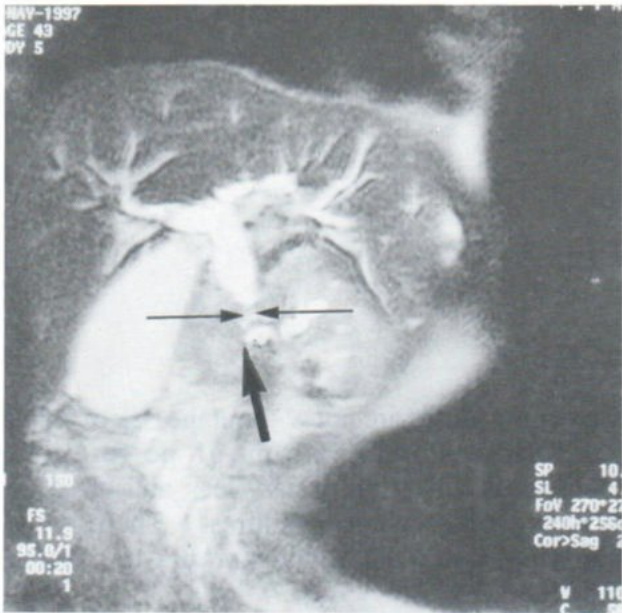




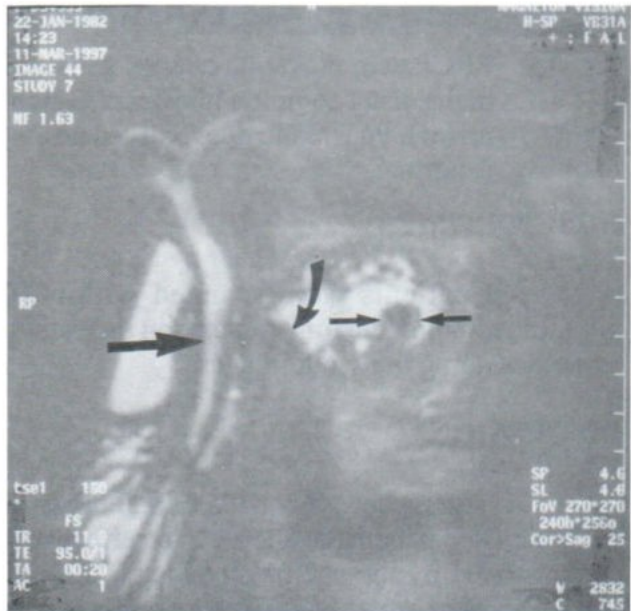
**Fig. 2A.** ERCP in a patient with carcinoma of the head of pancreas with strictured distal ends of common bile duct (long thin arrow) and pancreatic duct (thick short arrow).



**Fig. 3A.** 15 year old patient with chronic hereditary pancreatitis. Dilated proximal and mid pancreatic duct (thin short arrows) with two filling defects (calculi) (thick short arrow) within it.



**Fig. 2B.** MRCP with identical findings - 'the double duct sign' (arrows)



**Fig. 3B.** Dilated pancreatic duct with calculi (curved and short thin arrows) and normal common bile duct (long thick arrow).

**F. PANCREATIC DUCT PATHOLOGY**

Again the MRCP and ERCP findings concurred for the presence of strictures, dilatations and filling defects (Fig. 3a,b)



**F. INTRADUCTAL BILIARY PATHOLOGY**

There were 4 patients and 2 patients with filling defects in the CBD with intrahepatic ducts respectively which were equally well seen on both MRCP and ERCP (Fig. 4a,b). There was no filling defects in the common hepatic or cystic ducts. There were three patients with gallstones seen on MRCP while ERCP demonstrated only one because of incomplete filling of the gallbladder.



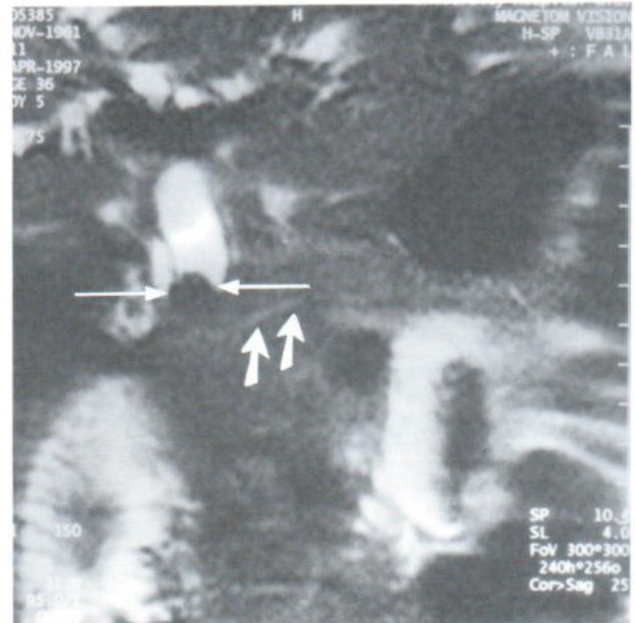
**Fig. 4A.** ERCP demonstrating a large gallstone in the distal common bile duct (straight arrow). Pancreatic duct (curved arrow) is normal.

**H.. SCAN TIMES**

All patients were scanned within 10 minutes including the time to position the patient as well as doing the scout images.

**DISCUSSION**

A significant proportion of pathology of the biliary and pancreatic ducts can be effectively demonstrated by the use of ultrasound, CT and MRI. There are however a subset of patients who would require the use of more invasive procedures like ERCP or PTC to help in making a definite diagnosis though not always for intervention.



**Fig. 4B.** MRCP demonstrating the same finding of a gallstone (long thin arrow) in the distal common bile duct. Normal pancreatic duct (thick straight arrows).

These procedures are not without the risk of small but serious complications of perforation, pancreatitis, infection, biliary leak and bleeding as well as the technical failures. There is the additional cost to the diagnostic work-up of these patients.

MRCP is a rapidly evolving efficient technique for imaging the biliary and pancreatic tree. Projectional images similar to ERCP or percutaneous transhepatic cholangiography (PTC) can be obtained without the use of contrast medium. The images are acquired using long T2



values which gives the bile and pancreatic fluid a high signal. Fluid within the spinal column, gastrointestinal tract lumen (including the consistent demonstration of mucosal detail) and the urinary tract will also be visualised. MRCP shows the calibre of the ducts at rest and therefore may not correlate precisely with the ERCP findings in which over- or underfilling commonly occur. The anatomical spatial resolution however does not match that of ERCP as well as the inability to perform intervention.

Numerous different methods have been reported by different authors to perform MR. Initially a 2-D T2 weighted gradient echo sequence using the steady state free precession (SSFP) during a breath-hold was used to produce images of the biliary ducts.<sup>26</sup> This was subsequently optimised to a 3-D volume acquisition.<sup>11</sup> 3-D MR imaging has been used because of the 3-dimensional nature of the biliary tree and the need for localisation and diagnosis. MRCP has evolved from the use of 3 dimensional breath-hold gradient echo in the steady state precession sequences (CE-FAST, SSFP)<sup>10-12</sup> to breath-hold thick slab RARE acquisition.<sup>13</sup> The former sequences despite being able to detect the presence of biliary obstruction suffered from a low signal to noise ratio, field inhomogeneity with susceptibility effects from bowel gas and surgical clips as well as the presence of blurring due to respiration. Takehara et al<sup>20</sup> developed a 2-D turbo-spin echo which was less susceptible to local inhomogeneities but suffered from breath-holds of 45-60 seconds. This was followed by the use of a respiratory-triggered three dimensional T2 weighted turbo spin-echo sequences.<sup>18</sup> This resulted in long scan times of about 11-16 minutes depending on the respiratory rate. Breath-hold thick slab RARE (rapid acquisition with repeated echoes) acquisition sequence with its breath-holding<sup>13</sup> (less than 16 seconds) have been able to overcome the artefacts due to respiration and achieve a higher signal to noise ratio. The limitation of this method of MRCP has been the inability to view any separate slices where the presence of any fluid filled structure within the imaging volume would generate signal and result in overlap. The presence of ascites would also be problematic since this fluid around

the extra-hepatic biliary tree would obscure the CBD and CHD.

This major problem with the use of thick slab breath-hold MRCP has been overcome by the use of the individual multi-slices in our study and other studies (23,28) in addition to the MIP images where we have had no false positives or negatives. Unlike a study by Regan et al<sup>23</sup> who used 2 sets of images in each axial, coronal and oblique sagittal. The use of this method of MRCP has not been fully explored. We did not evaluate the use of axial images in most of the patients but in several patients the additional conventional MR images done did not take much additional time. These could also be acquired using breath-hold sequences of less than 20 seconds each. Even though MIP images had to be generated from the thin-slice MRCP images this did not take much additional time, in fact the presence of individual slices allowed confirmation of the presence of obstruction, dilatation or filling defects with the MIP images providing an overall impression of the biliary and pancreatic tree rather being used for diagnosis most of the time.

HASTE is a half-Fourier acquisition single shot spin-echo technique.<sup>23</sup> It has been applied to MR urography, MR myelography and MR hysterosalpingography. An average of 13 slices/breath-hold / This yields heavily T2 weighted images. HASTE has low magnetic susceptibility to artefacts from bowel gas/respiration or surgical clips. This is a modification of the RARE sequence where the longitudinal magnetisation of the fully relaxed spin system is used.<sup>23</sup> Each slice image is acquired following a single excitation where slightly more than half the lines of K-space are acquired, with the remainder being extrapolated using a half-Fourier reconstruction. The signal drops by approximately 30%. Up to 128 echoes can be generated after a single excitation with each echo being individually phase encoded.

There was excellent suppression of background tissue with the use of frequency selective fat suppression on the breath-hold thin-slice MRCP sequences. The use of the individual slices also overcome the problem of volume



averaging with the use of breath-hold thick-slab sequences. The ability to use three different slabs as well as the ability to orientate the slabs in any direction allows one to ensure that the imaging volume is being sampled.

The reported accuracy of MRCP is difficult to compare with ERCP since there have been numerous different sequences used. In addition there has been ongoing software developments with shorter scan times. Good image quality, the number and location of biliary strictures, choledocholithiasis has been reported to be greater than 90%.<sup>1,5,6</sup> The sensitivity of classifying benign and malignant strictures is 50% and 80% respectively.<sup>1,3</sup> In our study the sensitivity and specificity of detecting biliary dilatation, strictures as well as intraductal filling defects was 100%. This may be due to the small sample size but we feel that the availability of the thin multi-slice images have been very helpful.

The presence of subcapsular fluid has not been previously reported. We have not been able to determine the cause of this appearance. This is not probably related to obstruction as there patients with and without biliary obstruction. This is not related to any intervention as the MRCP were done before ERCP. There was no evidence of hypoalbuminaemia or evidence of heart failure. We have also not noted this appearance during MR urography even in those patients with perinephric fluid. Further work needs to be done to ascertain the cause of these appearances.

The advantages of MRCP over ERCP are the total absence of invasiveness, ionising radiation, any form of contrast medium (which increases the safety as well as reducing the cost) or sedation as well as the shorter examination times. The procedure which we use can be completed within 10-15 minutes with the actual examination taking less than 5 minutes. MRCP is being carried out as an out-patient procedure without any preparation though in previous work patients were fasted<sup>23</sup> or were required to drink water to fill the duodenum.<sup>25</sup> No antiperistaltic drugs were used in our study,<sup>25</sup> but this has been used in a study by Laghi et al.<sup>25</sup> From the results

of our study we conclude that there is no real necessity for multiple acquisition as was done by Regan et al.<sup>23</sup> In addition the ability to perform conventional MRI studies at the same setting would obviate the need for any other form of imaging like CT or US. The cost of the MRCP at the University of Malaya Medical Center is approximately RM 300 compared to RM 1200 for a diagnostic ERCP since the procedure does not require the assistance of more than a single technician unlike ERCP. The demonstration of dilated ducts proximal to an obstruction may not always be well demonstrated with ERCP since this may result in an increased risk of infection.

Some of the reported potential problems with MRCP include those who are unsuitable for MRI e.g. pacemakers and claustrophobia. A major potential problem has inability of MRCP to differentiate stones from signal void due to aerobilia or mucus plugs.<sup>15</sup> Though it has not been reported there is the potential pitfall of haemorrhage or infection causing a change in the T2 values. The low spatial resolution of present MRCP methods do not allow for the visualisation of the smaller pancreatic ducts. This may therefore be a problem in the diagnosis of mild to moderate pancreatitis. However the ERCP features themselves do not correlate well with the actual clinical condition of pancreatitis.<sup>14</sup>

In our study the vast majority of patients were able to breath-hold for the duration of the scans despite some of them being elderly and quite unwell. We attribute this to proper instructions prior to the examination and some hyperventilation. This however may be problem in the very sickly. The further reduction in scanning times e.g. echo-planar imaging may reduce this problem. The use of single shot fast spin echo sequences where a single slice is acquired at a time within a second may also reduce the risk of respiratory misregistration.

Similar to a study by Beracraft et al<sup>13</sup> we found that the presence of fluid in the second part of the duodenum helpful in determining the position of ampulla and confirmation that the entire CBD had been visualised. However we



found that not fasting the patients prior to the MRCP did not obscure the ampulla or CBD due to the thin slices and may have been in fact been better. We feel that the lack of preparation may be another advantage of this breath-hold thin slice MRCP method.

A recognised limitation of this study was the there was a delay in the MRCP after ERCP but this was due purely due to logistical reasons. We however feel that this should not have made a difference since any interventions would resulted in decompression of the biliary tree any a loss of sensitivity of MRCP but on the other hand the injection of iodinate water soluble contrast medium in ERCP should resulted in false positives due to distension of the biliary tree. This was not the case in our study.

MRCP was able to diagnose accurately both the presence and level of biliary obstruction. In addition the demonstration of filling defects was also accurate. In the one patient despite the respiratory motion, diagnostic quality images were acquired. This compares with both a failure and complication of ERCP in one patient. In our 2 patients with pancreatic pathology MRCP and ERCP concurred in the detection of strictures, dilatations and filling defects.

The current status of MRCP may therefore reduce the need of ERCP in those patients with normal ducts and allow planning of the therapeutic ERCP by demonstrating the level and level of obstruction. The cause of dilatation can also be demonstrated. ERCP cannot be carried out in patients who have had had previous gastric surgery, gastric outlet obstruction, tight strictures of the biliary and pancreatic ducts.<sup>16,18,19</sup> There have also been suggestions that MRCP may be performed prior to laparoscopic<sup>17</sup> surgery to detect significant anatomical variants. MRCP may also have a role in the follow-up screening test in patients with suspected abnormality of the biliary and pancreatic duct system.<sup>21</sup>

## CONCLUSION

Breath hold thin slice Half Fourier turbo

spin echo (HASTE) MRCP has the ability to demonstrate both normal and abnormal biliary and pancreatic ducts. It's accuracy is equal if not better than ERCP without the risk and at a lower cost. In addition MRCP is able to evaluate the liver, pancreas and other abdominal organs cross-sectionally if so desired with very little increase

in the scanning times. We conclude that MRCP will be the non-invasive imaging modality of choice in the assessment of biliary and pancreatic duct pathology. It be the first line of investigation in these patients prior to proceeding to ERCP.

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