Magnetic resonance cholangio-pancreatography

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Magnetic resonance imaging can now offer a robust and non-invasive diagnostic alternative to the established imaging investigations of the biliary and pancreatic ducts. This article briefly reviews the underlying principles, technique, pitfalls and clinical applications.

Magnetic resonance cholangiopancreatography (MRCP) is becoming increasingly available to clinicians for non-invasive evaluation of the biliary and pancreatic ducts. The technique can provide diagnostic information comparable to diagnostic endoscopic retrograde cholangiopancreatography (ERCP) in a range of common clinical situations, such as suspected choledocholithiasis or stricture. This review outlines the underlying principles of the technique, how examinations are performed, typical indications, findings and pitfalls.

TECHNIQUE

MRCP has evolved rapidly over the last decade as a result of several technology developments that have allowed faster T2w imaging and specialized receiver coils providing improved signal to noise ratio. Early magnetic resonance attempts to image the biliary tree achieved promising results (Hall Craggs et al, 1993), but were often frustrated by motion and 'susceptibility' artefacts, the latter creating signal loss and image distortion where tissue–air interfaces occurred, such as around the stomach, duodenum and hepatic flexure.

IMAGE CONTRAST

The latest MRCP methods use a 'single shot' spin echo technique that acquires an image in approximately a second. This is ideal as it freezes peristaltic and breathing motion (Bearcroft et al, 1997). These techniques tend to emphasize long T2 value materials in the resulting images. This is an advantage for MRCP as water and related natural fluids such as biliary and pancreatic secretions have a long T2 value in relation to other tissues. The images are typically heavily T2 weighted by the use of a long 'echo time' (TE) that is far in excess (e.g. TE=600–1000 ms) of that used for conventional imaging (TE=30–120 ms). As a result, during the long TE the signal from the majority of body tissues (which have relatively short T2 values) decays away and only signal from fluid persists to create contrast in the images. Image contrast is therefore predominantly from static fluid, such as bile in the bile ducts.

This technique (termed by some 'magnetic resonance hydrography'; Ferrucci, 1998) has also been used to image native secretions in the salivary ducts, fistulae and more recently the small bowel. Some groups have used shorter TEs with the thin section approach, resulting in images with some signal visible from slow flowing venous blood and fat. Using this approach more sophisticated image processing with maximum intensity projections is often required, which adds to the overall examination time.

IMAGE DISPLAY

As magnetic resonance imaging (MRI) allows imaging in any plane and any thickness of image section, two methods of imaging the bile ducts have been used: projection or thick slab imaging and multiple thin section imaging. Slab imaging has the advantage of capturing the whole of a curvilinear fluid-filled structure such as the common bile or main pancreatic duct in a single image that is very similar to conventional ERCP images (*Figure 1*).

In these projection images good suppression of all the other tissues by means of a long TE and additional fat suppression techniques is particularly important. Thin slice images are helpful for working out complex ductal anatomy and adding confidence to any diagno-

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sis of intra-luminal filling defects such as calculi. On modern magnetic resonance systems both thick and thin section images can be obtained during a single examination lasting approximately 30 minutes.

PROCEDURE AND PATIENT PREPARATION

Patients lie supine in a whole body MRI system with a flexible 'torso' coil strapped to their upper abdomen. Initially some breath-hold conventional images are obtained to identify the adjacent anatomy and allow positioning of the subsequent MRCP images. The majority of the authors' current imaging technique involves breath-holds of 1–15 seconds, but diagnostic quality MRCP images can still be obtained even if the patient fails to breath-hold.

Patient preparation has not been well studied but in the authors' experience fasting before examination improves visualization by increasing the amount of fluid within the gallbladder, biliary and pancreatic ducts. Fasting also reduces fluid within the bowel, particularly the stomach, which may overlie the pancreatic ducts on projection images. However, the use of thinner slices, oblique sagittal images and careful slice positioning can avoid this problem. Some authors have advocated negative oral contrast agents to further reduce the signal from bowel secretions, but in the authors' experience this has proved unnecessary and may make interpretation of the downstream biliary and pancreatic duct anatomy more difficult by obscuring the duodenal wall and ampulla.

Contraindications to MRCP include the usual general exclusions for MRI such as cardiac pacemakers, retinal metal fragments or in some cases subarachnoid aneurysm surgical clips. Perhaps surprisingly it is usually possible to image the biliary and pancreatic duct systems successfully in the presence of many types of laparoscopic surgery clips and metallic biliary stents, although imaging in the immediate postoperative period is best avoided to reduce the theoretical small risk of displacement. Patients with ascites and intra-abdominal inflammation involving the retroperitoneum and mesentery can reduce image quality by generating background signal in the projection images. However, thin section images in these cases usually permit a diagnostic study to be performed.

It is worth emphasizing that the contraindications for ERCP and MRCP are different, allowing them to be employed as complementary techniques capable of imaging the pancreatico-biliary ducts in virtually all types of patients.

ANATOMICAL VARIANTS AND CONGENITAL LESIONS

MRCP may demonstrate the presence of a pancreas divisum and an accessory pancreatic duct (Bret et al, 1996), although relatively small ducts without much fluid secretion within may be overlooked. This problem is likely to be

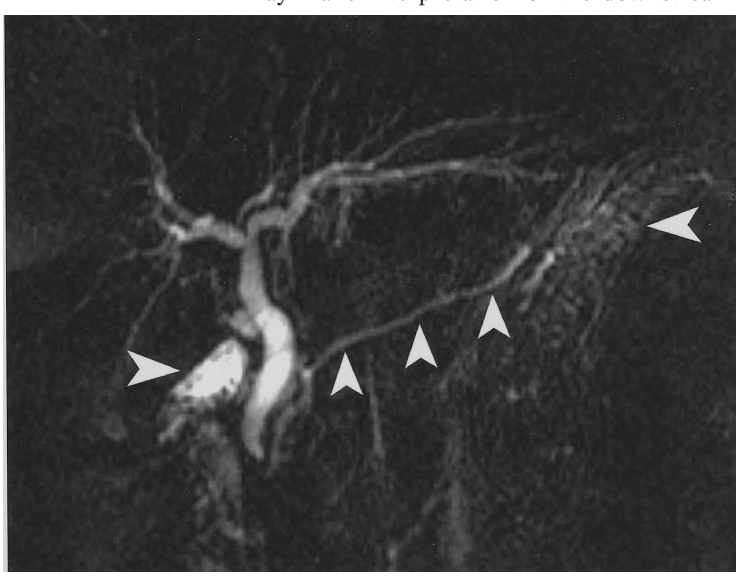

Figure 1. A thick slab (40 mm) magnetic resonance cholangiopancreatography image of a normal biliary and pancreatic duct system. Note the fluid in the stomach and duodenum (horizontal arrowheads) and the main pancreatic duct (vertical arrowheads), side branches are not normally visualized with current techniques.

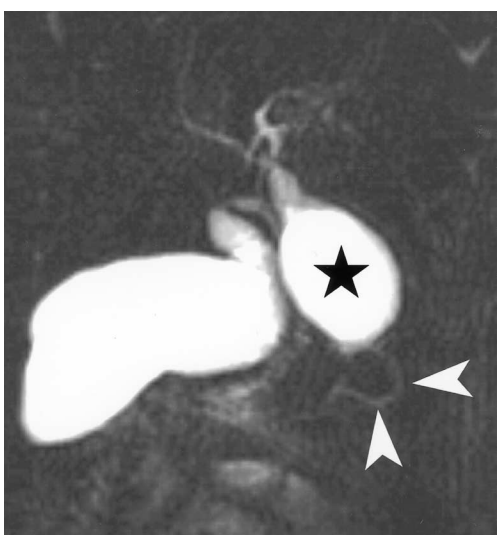

Figure 2. A thick slab (40 mm) magnetic resonance cholangiopancreatography of a choledochal cyst demonstrating clearly the dilated section of common bile duct (star) and the normal calibre distal duct (arrowheads).

improved by the administration of secretin, although this specific question has not been studied. Low inserting cystic ducts may also be relatively easily visualized, information that may be helpful before laparoscopic cholecystectomy (Taourel et al, 1996). Choledochal cysts (*Figure 2*) are also well defined anatomically using MRCP (Irie et al, 1998).

BILIARY OBSTRUCTION

Several studies have confirmed that the diagnostic performance of MRCP is comparable to ERCP for the demonstration of biliary obstruction, both with regard to the presence of obstruction and the underlying aetiology, i.e. calculi and strictures.

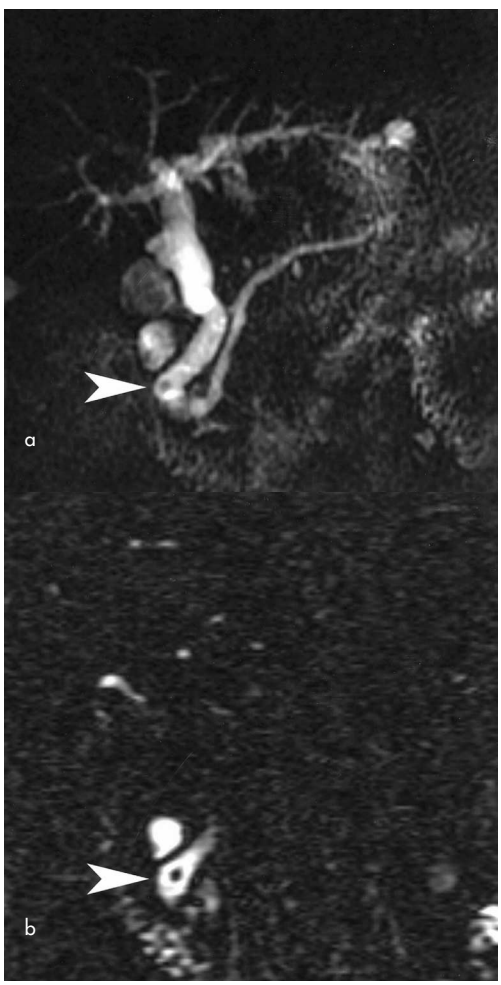

Figure 3. A symptomatic patient with suspected choledocholithiasis. a. 40 mm thick projection image demonstrates intrahepatic and extrahepatic duct dilatation and a probable filling defect (arrowhead) in the distal common bile duct. b. A 3 mm thick image from a block of similar images confirms the presence of a filling defect, a calculus removed at subsequent therapeutic endoscopic retrograde pancreatography.

CHOLEDOCHOLITHIASIS

Calculi in general lack protons, do not generate MR signal and therefore appear as filling defects within the fluid-filled high signal ducts at MRCP (*Figure 3*). Several studies indicate MRCP has a similar performance to ERCP with comparable sensitivity and specificity in blinded trials using both procedures (*Table 1*). These series suggest that MRCP has a role in the assessment of patients before cholecystectomy. In patients at increased risk of choledocholithiasis, on the basis of history, liver blood tests and abdominal ultrasound examination, MRCP may accurately predict the presence or absence of common duct calculi and may avoid unnecessary ERCPs in up to 66% of patients (Dwerryhouse et al, 1998; Liu et al, 1999).

Similarly MRCP is likely to have a role in assessing patients with post-cholecystectomy pain where ultrasound has low sensitivity for detecting the 10% of patients with choledocholithiasis. Formal randomized controlled trials of ERCP and MRCP involving large numbers of patients have yet to be undertaken, but a complicating factor in comparison studies is that diagnostic ERCP is an imperfect reference standard and overall outcomes incorporating surgical findings over a reasonable follow-up period are required.

BILIARY STRICTURES

Main duct strictures, benign and malignant, are well demonstrated by MRCP (*Figure 4*) and the major advantages are the ability to delineate the site of biliary obstruction, Bismuth classification and to define obstructed biliary ducts without the need to introduce contrast media, unlike ERCP where this may not be technically possible and may introduce infection (Yeh et al, 2000).

TABLE 1.
Choledocholithiasis detection by magnetic resonance cholangiopancreatography

Reference	Sensitivity	Specificity	Positive*	Population
Boraschi et al (1999)	92%	97%	76	278
Varghese et al (1999)	91%	97%	34	191
Fulcher et al (1998)	100%	100%	14	117
Lomas et al (1999)	100%	97%	9	69
Becker et al (1997)	90%	95%	23	108
Soto et al (1996)	100%	100%	10	44
Chan et al (1996)	95%	85%	19	45
Regan et al (1996)	93%	89%	15	23
Guibaud et al (1995)	86%	98%	14	123

*number of patients with confirmed calculi

In a recent series, information from MRCP would have altered management options and the position of stent placement in 28% of cases (Zidi et al, 2000). MRCP is also comparable to endoscopic ultrasound (Materne et al, 2000). Intrahepatic strictures and duct irregularity as seen in sclerosing cholangitis are less well demonstrated, particularly when the disease is early (Ito et al, 1999). This potentially limits the application of MRCP in conditions such as early primary sclerosing cholangitis, although there are several possible technical refinements that may improve the spatial resolution of the technique. MRCP has allowed the delineation of congenital abnormalities including both pancreas divisum and anomalous pancreaticobiliary junctions (Sugiyama et al, 1998).

PANCREATIC DUCT ABNORMALITIES

MRCP can demonstrate main duct and side branch dilatation in established chronic pancreatitis (*Figure 5*) along with pancreatic duct calculi when present. However, the moderate spatial resolution of the technique and the inability to monitor the changes in duct calibre following injections of contrast medium limit the role of MRCP in the diagnosis of early chronic pancreatitis.

In a comparison study with ERCP (Lomas et al, 1999) the MRCP examinations could not detect the subtle changes that led to a diagnosis of early chronic pancreatitis in three of four cases. Studies augmented by intravenous secretin injection indicate an improvement in visualization of the pancreatic duct (Matos et al, 1997), although the actual diagnostic value of this manoeuvre remains to be determined. MRCP has proven of value for demonstrating the remaining duct following partial pancreatic resection and for defining mucin-producing tumours and their relationships to the duct system (Ueno et al, 1998).

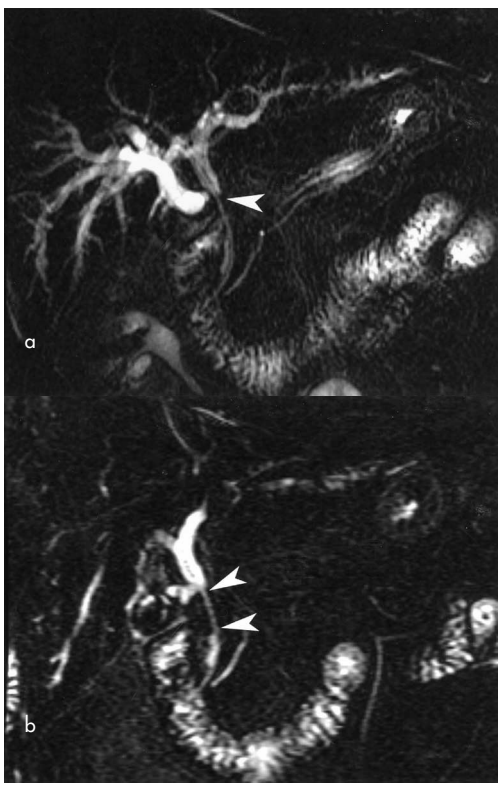

Figure 4. A patient with suspected cholangiocarcinoma following stent insertion and persisting symptoms. a. 40 mm thick image demonstrates intrahepatic duct dilatation arising from the main duct confluence (arrowhead). The stent is visible extending from the left main duct through the stricture to the duodenum. b. 5 mm thick image demonstrating more clearly the extend of the shouldered stricture (arrowheads) and confirming the presence of fluid within the stent passing through the stricture.

PITFALLS

In younger patients the duct systems are frequently of smaller calibre and contain less bile, making them more difficult to visualize (Fulcher and Turner, 1998). Where the T2 of bile is reduced, for example by infection or haemorrhage, then duct visualization may be impaired. Gas within the ducts appears as a filling defect

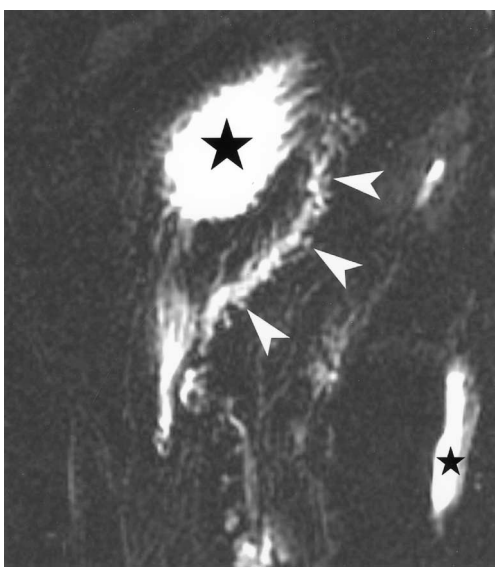

Figure 5. A patient with suspected chronic pancreatitis. An oblique sagittal 40 mm thick image (the anterior of the patient is to the left of the image and posterior to the right) demonstrates dilatation of the main pancreatic duct and side branch dilatation consistent with established chronic pancreatitis. Note the fluid in the stomach (large star) and the cerebrospinal fluid around the spinal cord (small star).

and may therefore lead easily to a false positive diagnosis of duct calculi in a similar fashion to ERCP. Shape, gravity dependence and the appearances on other techniques such as ultrasound and computed tomography may help avoid this pitfall.

Distortion of the ductal anatomy as a result of prior gastric, pancreatic or liver transplantation surgery may be confusing, especially as the native duct may be visualized in patients with a roux loop. In these cases fluid (water) in the duodenum and proximal small bowel often aids diagnosis and delineation of the anatomy (Pavone et al, 1997).

FUTURE DEVELOPMENTS

There will be improvements in the spatial resolution of MRCP that may in turn improve evaluation of the pancreatic ducts and subtle intrahepatic duct changes. Functional evaluation of pancreatic secretion using secretin is being studied and with good temporal resolution now possible (an image per second) functional studies of the biliary tract are also possible. Further work is required to improve the discrimination of air bubbles from calculi. Ongoing studies will help further refine the place of MRCP in the clinical investigation of pancreaticobiliary disease. HM

Conflict of interest: none.

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KEY POINTS

- Magnetic resonance cholangiopancreatography (MRCP) is a rapid, conceptually simple and completely non-invasive technique.
- The technique relies upon the large T2 value of fluids and secretions.
- Static native secretions within the biliary and pancreatic ducts are imaged by magnetic resonance.
- Results are comparable to diagnostic endoscopic retrograde cholangiopancreatography (ERCP) for detection of choledocholithiasis and strictures.
- Accuracy is limited in early chronic pancreatitis.
- MRCP is particularly suitable for patients in whom diagnostic ERCP is hazardous or impractical.