Preoperative diagnosis of choledocholithiasis: the role of MRCP

Biliary imaging has changed as a result of technological advances, but the timing and modality of preoperative biliary tree imaging is controversial. An ideal imaging modality would be risk free and have a high sensitivity and specificity, a role fulfilled by magnetic resonance cholangiopancreatography (MRCP).

Cholecystectomy for gallstone-associated diseases is commonly performed in the UK (Somasekar et al, 2002). The frequency of gallstones in Britain is difficult to assess. Bateson (2000) showed that about 12% of British females in their 40s have gallstones, while in males the prevalence is about 5% in the same age group. The prevalence increases with age, and could be up to 48% in males and females in their 90s. Gallstones lodged in the common bile duct cause biliary obstruction and patients present with altered liver function tests, jaundice, fever, itching and right upper quadrant pain. Choledocholithiasis can lead to complications such as acute biliary pancreatitis, obstructive jaundice or ascending cholangitis. These complications carry significant morbidity, so the common bile duct must be free of obstruction. Traditionally, endoscopic retrograde cholangiopancreatography (ERCP) has been performed preoperatively in selected patients with common bile duct obstruction as a diagnostic and/or a therapeutic tool.

ERCP demonstrates the biliary tree anatomy for diagnostic purposes and the common bile duct can be cleared of stones via sphincterorotomy or stenting (*Figure 1*). Nevertheless, ERCP is invasive and complications like pancreatitis and bowel perforation occur in 5–10% of cases (Pannu and Fishman, 2001). Therefore, it is preferable to perform this preoperatively only when the presentation is highly suspicious of common bile duct stones. When choledocholithiasis is less likely, non-invasive imaging is favoured, e.g. ultrasound. The sensitivity of ultrasound in detecting common bile duct stones varies from 23–80% depending on the patients' body habitués and operator experience (Garden, 2005). This has raised the possibility of using a more sensitive non-invasive imaging tool such as magnetic resonance cholangiopancreatography (MRCP) to detect common bile duct stones in selected patients.

Magnetic resonance imaging of the biliary system is customized to visualize the biliary fluid or duct walls (*Figures 2–6*). The stones are seen as filling defects surrounded by bright bile. It is performed by using heavily T2 weighted (which shows water as bright) sequences to visualize the stationary or slow-moving fluids in the pancreaticobiliary system, with high signal intensity (Zhong et al, 2004). It takes about 20 minutes and consists of either breath-held two-dimensional sequences or respiration-triggered three-dimensional sequences. Post processing is performed to produce maximum-intensity projections. These should be viewed with two-dimensional sequences.

Figure 1. Large distal common bile duct stone during endoscopic retrograde cholangiopancreatography.

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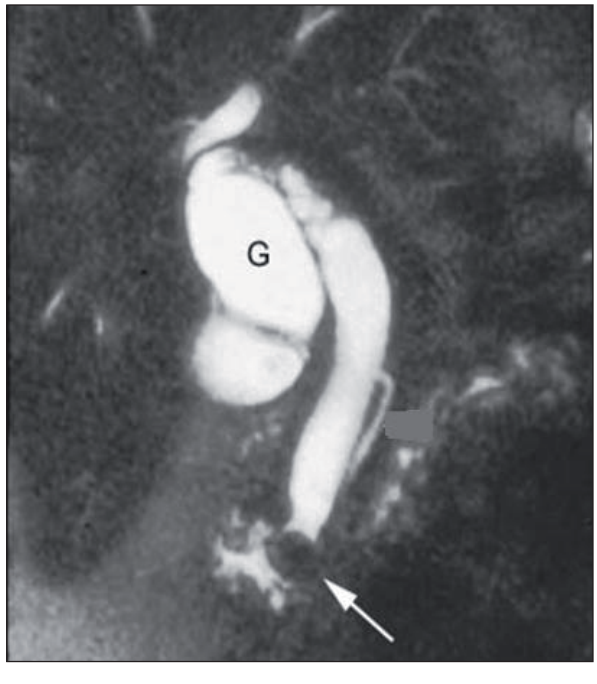
MRCP can create projectional images similar in detail and appearance to direct cholangiography, with high resolution of the bile ducts and intraductal stones (Makary et al, 2005). The major advantage of MRCP over ERCP is that it can demonstrate the ducts proximal to an obstruction and show stones at this site, so can be used to guide percutaneous cholangiogram if necessary. It produces images of the pancreaticobiliary ducts, up to the first order branches, in their natural state, rather than with the distension caused by contrast in ERCP (Zhong et al, 2004). Also, there is no need for sedation or patient preparation. MRCP is particularly useful when ERCP has failed, is high-risk or the patient prefers a non-invasive investigation. The main disadvantage is that MRCP is entirely diagnostic, whereas ERCP can be diagnostic and therapeutic. In addition, the spatial resolution of MRCP is lower than ERCP but the higher contrast resolution allows very small stones to be detected. The pitfalls in the diagnosis of biliary calculi via MRCP include the presence of biliary prostheses, clips, aerobilia, haematobilia or incrustations, which could cause false positive results as they could be mistaken for a stone.

This review examines the evidence for the use of MRCP for the preoperative diagnosis of choledocholithiasis and evaluates its sensitivity and specificity.

Figure 2. Normal magnetic resonance cholangiopancreatography.

Figure 3. Large distal common bile duct stone on magnetic resonance cholangiopancreatography (arrow). G = distended gallbladder.



Results

Ten studies were included in this review (*Table 1*).

De Waele et al (2007) conducted a prospective observational study to value the role of MRCP in pre-cholecystectomy detection of common bile duct stones in 104 acute biliary pancreatitis patients. Patients with confirmed cholelithiasis on ultrasound scan and acute biliary pancreatitis were included in this study. The overall accu-

Figure 4. Acute cholecystitis with stones in the neck of the gall bladder on magnetic resonance cholangiopancreatography.

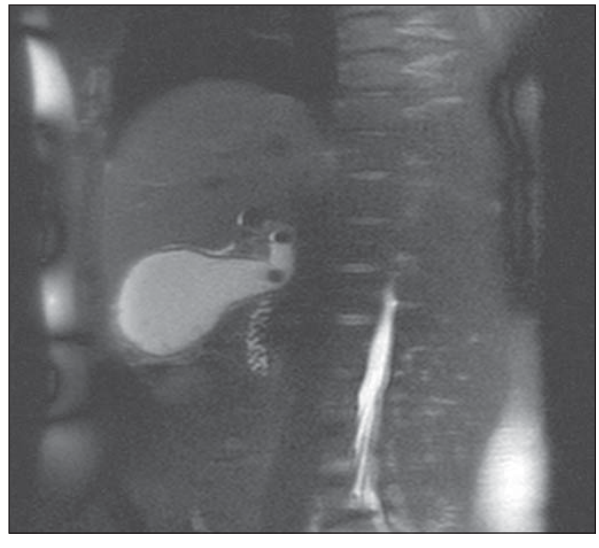
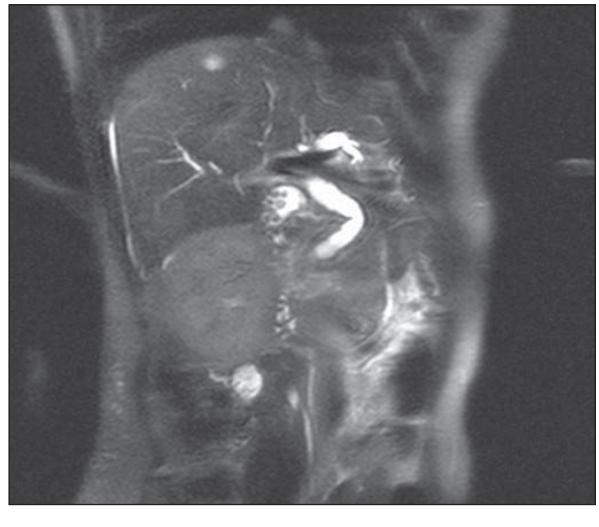


Figure 5. Gall bladder calculi and dilated common bile duct caused by a stone at its distal end on magnetic resonance cholangiopancreatography.



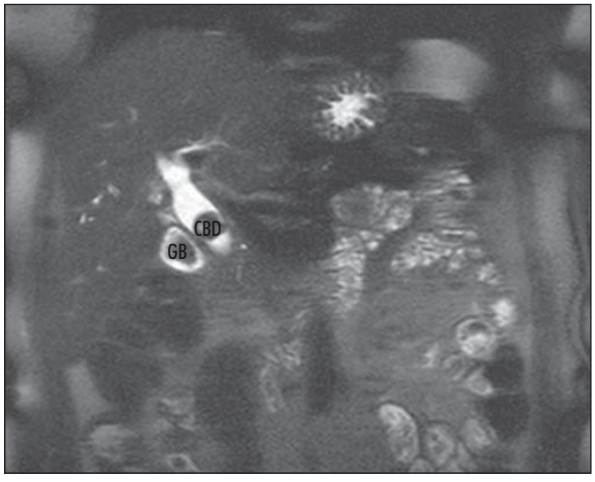


Figure 6. Big stone in the gall bladder (GB) and big stone in the common bile duct (CBD) on magnetic resonance cholangiopancreatography.

racy of MRCP in detecting common bile duct stones was measured by using ERCP as the reference. They concluded that MRCP (with a sensitivity of 82.6% and specificity of 97.5%) is highly accurate in the preoperative detection of common bile duct stones. This study indicated that MRCP had high sensitivity and specificity in detecting common bile duct stones. The MRCP images were analysed by a senior radiologist specialized in gastrointestinal magnetic resonance, which contributed to the reliability of this study. Acute biliary pancreatitis diagnosis was based on raised serum amylase levels, which is not always dependable: hyperlipidaemia or delayed presentation might cause inaccurate or low readings respectively, which could cause selection bias. Serum lipase or serum trypsin levels are more accurate laboratory indicators for pancreatitis (Munoz and Katerndahl, 2001). The inclusion of these diagnostic markers would have strengthened the study further.

Mercer et al (2007) evaluated the role of MRCP in detecting common bile duct stones in 89 consecutive cases with suspected choledocholithiasis. A clinical algorithm was used to select patients for MRCP or ERCP with or without sphincterotomy before surgery. High probability patients proceeded directly to ERCP for stone removal. Patients with equivocal signs underwent MRCP. Patients with choledocholithiasis on MRCP proceeded to ERCP for common bile duct clearance. They concluded that MRCP was effective in detecting choledocholithiasis.

ERCP and cholecystectomies were performed under the same conditions by the same group of clinicians, decreasing the possibility of performance bias. It was not mentioned whether the same group of radiologists were involved in interpreting the MRCP images or not. The false positive result rate for MRCP was 6.7%, which could be explained either by the passage of stones or misinterpretation of MRCP images. These results indicate that MRCP has a high sensitivity and specificity in detecting common bile duct stones compared to ERCP. Moreover, 60 (67%) patients did not have unnecessary ERCPs and avoided its possible complications. None of the patients who underwent cholecystectomy after confirmation of common bile duct clearance (by MRCP or ERCP) had recurrent symptoms as a result of retained stones.

Mofidi et al (2008) conducted a retrospective study of the role of MRCP in the management of 49 patients with acute biliary pancreatitis who had dilated common bile duct and/or obstructive jaundice. They compared the outcome and hospital stay length of these patients with those of 57 acute biliary pancreatitis patients who underwent ERCP where MRCP was not available. They concluded that selective use of MRCP reduced the need for ERCP and resulted in shorter hospital stay ($P<0.01$). Moreover, a higher number of cholecystectomies were performed during the same admission for patients having MRCP (MRCP 83.3% *vs* ERCP 67.2%, $P<0.05$).

Table 1. Studies evaluating the sensitivity and specificity of magnetic resonance cholangiopancreatography in diagnosing choledocholithiasis

				Results				
Reference	Study type	No of patients	Statistics	Sensitivity	Specificity	PPV	NPV	Overall accuracy
Ausch et al (2005)	Prospective	773	Median	94.0%	98.0%	80%	99.0%	
De Waele et al (2007)	Prospective	104	Mean	82.5%	97.5%	90.5%	95.2%	94.2%
Griffin et al (2003)	Prospective	115		84.0%	96.0%	91.0%	93.0%	92%
Hallal et al (2005)	Prospective randomized trial	29	$P<0.05$	100.0%	91.0%	50.0%	100.0%	92.0%
Mercer et al (2007)	Prospective	89				?	100.0%	>95.0%
Ke et al (2003)	Retrospective	267	$P<0.001$	100.0%	96.3%	91.8	100.0%	
Makary et al (2005)	Cohort	64		94.0%	98.0%	94.0%	98.0%	
Mofidi et al (2008)	Retrospective	49	$P<0.01$	100.0%	96.0%			
Moon et al (2005)	Retrospective	32	$P<0.01$*	80.0%	83.3%	88.9%	71.4%	81.3%
Topal et al (2003)	Retrospective predictive model	315	$P\leq0.05$	95.0%	100.0%	100.0%	98.0%	

* Cohen's K = 0.808. NPV = negative predictive value; PPV = positive predictive value

Topal et al (2003) conducted a retrospective study to evaluate pre-intervention MRCP in 285 patients with high suspicion of having common bile duct stones. They concluded that MRCP had a sensitivity of 95% and specificity of 100% in detecting common bile duct stones. The pre-cholecystectomy MRCP findings correlated with the intraoperative cholangiogram in selected (84) patients who had a possibility of retained common bile duct stones from imaging or initial clinical presentation. Intraoperative cholangiogram found common bile duct stones in only seven patients. However, use of the intraoperative cholangiogram in selected patients has a sensitivity of 50% and specificity of 100% compared to routine intraoperative cholangiogram which has a sensitivity of 97.4% and specificity of 100% (Nickkholgh et al, 2006). Patients at risk of having common bile duct stones were followed up to about 25 weeks. However, the authors did not clarify the mode of follow up or if any of the patients had common bile duct stones and whether it altered the final outcome.

Moon et al (2005) conducted a prospective study to evaluate the sensitivity of pre-intervention MRCP for choledocholithiasis in 32 patients with acute biliary pancreatitis who underwent MRCP followed by ERCP and intraductal ultrasound. MRCP has a sensitivity of 80.0% and specificity of 83.3%. They concluded that MRCP can be used to select patients with acute biliary pancreatitis for ERCP and that intraductal ultrasound applied along with ERCP improves patient outcomes. Intraductal ultrasound is effective in diagnosing microlithiasis, thus identifying the need for subsequent intervention. It has 93% sensitivity and 97% specificity for choledocholithiasis (Rizk and Gerke, 2007). This decreases the possibility of missing small common bile duct stones and can be used as a dependable reference to evaluate MRCP results.

Ke et al (2003) conducted a prospective study to evaluate the role of MRCP in 276 patients with a high suspicion of choledocholithiasis awaiting a cholecystectomy. Of these patients, 78 had common bile duct stones and proceeded to have an ERCP. MRCP has 100% sensitivity and 96.3% specificity in detection of common bile duct stones, and reduced the need for ERCP by 68.2%. Griffin et al (2003) undertook a prospective study to compare the preoperative diagnostic role of MRCP with ERCP in 115 patients with a high suspicion of having common bile duct stones. In this study, MRCP had a high sensitivity (86%) and specificity (96%) for stones larger than 5 mm in diameter. The study also revealed that small common bile duct stones (≤5 mm) decrease the sensitivity of MRCP (5.22 false negative results compared to 2.61 with ERCP). Similar findings have also been reported by other studies (Rondeau et al, 1998; Kondo et al, 2005), raising questions about the need for further imaging with intraoperative cholangiogram or following up patients on a long-term basis.

Makary et al (2005) performed a retrospective study to evaluate the role of MRCP in preoperative evaluation of 64 patients diagnosed with acute biliary pancreatitis. Seventeen patients (27%) had common bile duct stones which were confirmed by ERCP. The authors concluded that MRCP could accurately identify common bile duct stones in preoperative patients with acute biliary pancreatitis with a sensitivity of 94% and specificity of 98%. Ausch et al (2005) conducted a prospective study to evaluate the role of routine MRCP in detecting common bile duct stones preoperatively in 773 patients who underwent cholecystectomy. All patients had cholelithiasis confirmed by preoperative ultrasound. They found that MRCP had a sensitivity of 94% and a specificity of 98% compared to ERCP. In this study all patients underwent MRCP, which may not be possible in most hospitals because of economic and/or time constraints. Some studies support preoperative routine MRCP, as it may influence therapeutic decisions (Varghese et al, 2000). The patients in this study had a longer follow up; 532 patients (71%) had a median follow up of 54 weeks which strengthened the study. Postoperative follow up found false-negative results in three cases (0.4%) that required ERCP for stone extraction.

Hallal et al (2005) evaluated the role of MRCP in detecting choledocholithiasis in patients with resolving acute biliary pancreatitis by conducting a prospective randomized trial. Group 1 (n=34) underwent laparoscopic cholecystectomy and intraoperative cholangiogram, group 2 (n=29) had preoperative MRCP; of these, patients with negative MRCP underwent laparoscopic cholecystectomy and intraoperative cholangiogram. Patients with positive MRCP in group 2 had preoperative ERCP followed by laparoscopic cholecystectomy. The trial showed that MRCP had a sensitivity of 100% and specificity of 91 (P<0.05). The sample size was relatively small and the authors did not mention whether the same group of radiologists, endoscopists or surgeons were involved in the trial.

Discussion

Diagnosis of choledocholithiasis (symptomatic or silent) before cholecystectomy has become more challenging since the advent of laparoscopic cholecystectomy. This may help avoid potential intraoperative difficulties leading to forced conversions as a result of lack of equipment or skill. Intraoperative cholangiograms can add to operating time and costs and require specialist skills and equipment as they are not routinely performed by many consultants. They may not benefit the patient if equipment for laparoscopic stone retrieval is not available.

ERCP has been the gold standard for biliary imaging but can have a failure rate of up to 25% (Shanmugan et al, 2005). It can also cause complications like bleeding, pancreatitis and duodenal perforation, and can be problematic in elderly and frail patients. Biliary tree imaging has undergone significant changes as a result of advances in diagnostic tools and techniques (Bar-Meir, 2001). MRCP offers a safer alternative to ERCP. It is non-invasive and does not have the contraindications of use in patients with metallic body implants or claustrophobia, but it is more expensive than ultrasound or ERCP. It also has the added advantage

of diagnosing congenital biliary anomalies cholangiocarcinoma and common bile duct injury (*Figure 7*).

MRCP has a high sensitivity (range 80–100%) and specificity (range 83–98%) for picking up choledocholithiasis. Moreover it decreases the need for ERCP and hence avoids its possible complications.

MRCP depends on the available equipment and interpretation skills of the radiologist. Despite this its results compare favourably to those of ERCP. Correlation of the initial clinical presentation and biochemistry findings with imaging could identify patients at risk of having retained common bile duct stones after surgery, who might need further imaging like intraoperative cholangiogram, intraductal ultrasound and a longer follow up. The paucity of quality data dictates the need for more randomized trials to compare the efficiency of MRCP to intraoperative cholangiogram or intraductal ultrasound.

Compared with imaging techniques, MRCP is non-invasive, simple, safe and does not require ionizing radiation or administration of contrast agents. Moreover MRCP can be combined with other magnetic resonance including conventional cross-sectional magnetic resonance imaging and magnetic resonance angiography, which can be used in the perioperative period of pancreaticobiliary disease (Zhong et al, 2004). It is also valuable in surgical bypass procedures such as gastrectomy, hepatojejunostomy and in patients with acute pancreatitis.

Conclusions

Overall, preoperative use of MRCP in patients with suspicion of having common bile duct stones is feasible and highly recommended. **BJHM**

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Figure 7. Transected common bile duct (iatrogenic).

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KEY POINTS

- Magnetic resonance cholangiopancreatography has a high sensitivity and specificity in detecting stones in the common bile duct.
- Magnetic resonance cholangiopancreatography combines the advantages of being non-invasive, simple, safe and not requiring ionizing radiation or administration of contrast agents.
- The main disadvantage of magnetic resonance cholangiopancreatography is that it is only diagnostic whereas endoscopic retrograde cholangiopancreatography can be diagnostic and/or therapeutic.