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Biliary stones and stenoses: Diagnostic value of magnetic resonance cholangiography

Safra yolu taşı ve stenozlarında manyetik rezonans kolanjiografinin tanısal değeri

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Background/aims: *To evaluate the accuracy of magnetic resonance cholangiography for detection of bile duct calculi and stenosis.* ***Methods:*** *Half-Fourier single-shot rapid acquisition with relaxation enhancement sequence magnetic resonance cholangiography was performed prospectively in 68 patients who were suspected of having choledocholithiasis or biliary tree stenosis. On the basis of findings at ultrasound, computed tomography, endoscopic retrograde or percutaneous cholangiography, intraoperative cholangiography or choledocoscopy and exploration, final diagnoses were normal bile ducts (n=8), choledocholithiasis (n=28), benign or malignant stenosis (n=32).* ***Results:*** *Choledocholithiasis was diagnosed with a sensitivity of 96% and a specificity of 98%. False negative readings occurred due to stones less than two mm at in size at the distal common bile duct. A false diagnosis of choledocholithiasis (single impacted stone) by magnetic resonance cholangiograph occurred in only one case for whom the final diagnosis was main bile duct adenocarcinoma, suspected on endoscopic retrograde cholangiography and confirmed at surgery. Bile duct stenosis was diagnosed with a sensitivity of 97% and a specificity of 94%.* ***Conclusions:*** *With magnetic resonance cholangiography, bile duct calculi and stenosis can be diagnosed with high accuracy. It is a fast, accurate and noninvasive alternative to endoscopic retrograde cholangiography in the evaluation of biliary tract disease.*

Key words: Magnetic resonance cholangiography, choledocholithiasis, bile duct stenosis.

Amaç: *Koledok taşı ve safra yolları tıkanmalarında magnetik rezonans kolanjiografinin tanısal değeri irdelenmiştir.* ***Yöntem:*** *Koledok taşı ve safra yolu tıkanması düşünülen 68 hastaya prospektif olarak half-Fourier single-shot rapid acquisition with enhancement sekans magnetik rezonans kolanjiografi yapıldı. Magnetik rezonans kolanjiografiyi takiben hastalara ultrason, kompüterize tomografi, endoskopik kolanjiografi, perkutan kolanjiografi, intraoperatif kolanjiografi (veya koledokoskopi) ve cerrahi eksplorasyon bulguları sonucu kesin tanıya varıldı. Kesin tanı sonucu 28 hastada koledok taşı, 32 hastada benign veya malign safra yolu obstrüksiyonu, 8 hastada ise normal safra yolu mevcuttu.* ***Bulgular:*** *Kolelithiasis tanısında magnetik rezonans kolanjiografinin %96 sensitif, %98 spesifik olduğu görüldü. Bir hastada koledok distalindeki < 2 mm taş magnetik rezonans kolanjiografide vizualize edilemedi. Bir hastada ise koledok tümörü impakte taş olarak değerlendirildi. Benign veya malign safra yolu stenozunda magnetik rezonans kolanjiografinin %97 sensitif, %94 spesifik olduğu belirlendi.* ***Sonuç:*** *Koledok taşı ve safra yolları obsrüksiyonlarında magnetik rezonans kolanjiografinin yüksek bir tanısal değeri vardır. Basit, noninvazif ve güvenilir olması nedeniyle magnetik rezonans kolanjiografi safra yolu obsrüksiyonunun ayırıcı tanısında endoskopik retrograd kolanjiografiye alternatiftir.*

Anahtar kelimeler: Magnetik rezonans kolanjiografi, koledokolithiasis, safra yolu stenozu.

INTRODUCTION

Magnetic resonance (MR) cholangiography is a non-invasive method used to visualise the bile ducts without use of contrast material. It is based on the principle that stationary fluids are hyperintense on heavily T2 weighted images, and has several advantages over the established non-invasive imaging techniques, including the absence of known side effects. Endoscopic retrograde cholangiopancreatography (ERCP) is currently the standard method for delineating the bile duct system. Diagnostic ERCP is associated with a small but significant risk of complications (1-4). It is therefore appropriate to use MR cholangiography for diagnostic purposes and to restrict ERCP to those cases in which endoscopic interventions are anticipated.

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Table 1. Final diagnosis in 68 patients

Diagnosis	*n*
Normal biliary tree	8
Acute pancreatitis	2
Biliary cirrhosis	2
Acute cholecystitis	4
Choledocholithiasis	28
Benign stricture (or obstruction)	15
Chronic pancreatitis	2
Papillary stenosis	4
Bilioenteric stricture	4
Hilar tortion	2
Communicated hydatid cyst	2
Caroli disease	1
Malignant stricture	17
Hilar carcinoma	2
Metastatic hilar carcinoma	2
Intrahepatic carcinoma	1
CBD carcinoma	5
Gallbladder carcinoma	2
Ampullar carcinoma	2
Cephalic pancreatic carcinoma	3

The aim of this study was to evaluate MR cholangiography in the diagnosis of biliary tree obstruction in a representative number of patients. Our prospective protocol was inspired by routine hospital practice. A half-Fourier single-shot rapid acquisition with relaxation enhancement (RARE) sequences MR cholangiography technique was used. Final diagnosis was established by ultrasound (US), computed tomography (CT), ERCP, percutaneus transhepatic cholangiography (PTC), intraoperative cholangiography (or choledocoscopy) and surgical exploration.

MATERIALS AND METHODS

From September 1998 to January, 2002, MR cholangiography examination was performed on 68 patients who had either clinical signs or showed laboratory evidence consistent with biliary tract obstruction. Four of the initial 72 patients were excluded because of uncertainity in final diagnosis. The remaining 68 patients included 29 men and 39 women, having a mean age of 52.9 years (range: 22-83 years). The patients underwent US (n=68), CT (n=14), ERCP (n=33), PTC (n=2) and biliary surgery (n=16). All MR cholangiographies were evaluated individually by a single radiologist.

Imaging Technique

All MR cholangiography examinations were performed on a 1.5-T whole-body system (Magnetom Symphony: Siemens, Erlangen, Germany) with a half-Fourier single-shot rapid acquisition with relaxation enhancement (RARE) sequence with breath-hold technique. A body phased-array coil with four channels was used for signal reception. The circular surface coil provided a good signal of the biliary tree with satisfactory spatial resolution and a homogeneous signal in the upper abdomen. Prior to MR chlangiography, T1-weighted axial gradient-echo imaging was performed to locate the biliary system. Diagnosis was made on source images obtained in the coronal sequence. The MR cholangiography images were assessed for overall quality and visualization of the entire biliary tree and evaluated for the presence of main bile duct dilation, choledocholithiasis, benign obstruction or stricture and malignant stricture on a yes/no basis. A normal biliary tree was defined as the absence any biliary imaging abnormality. Intrahepatic bile duct dilation was evaluated subjectively, main bile dilation was defined as a diameter equivalent to or greater than 7mm or equivalent to or greater than 9 mm in patients above the age of 75 years or with a past history of cholecystectomy or bilioenteric bypass.

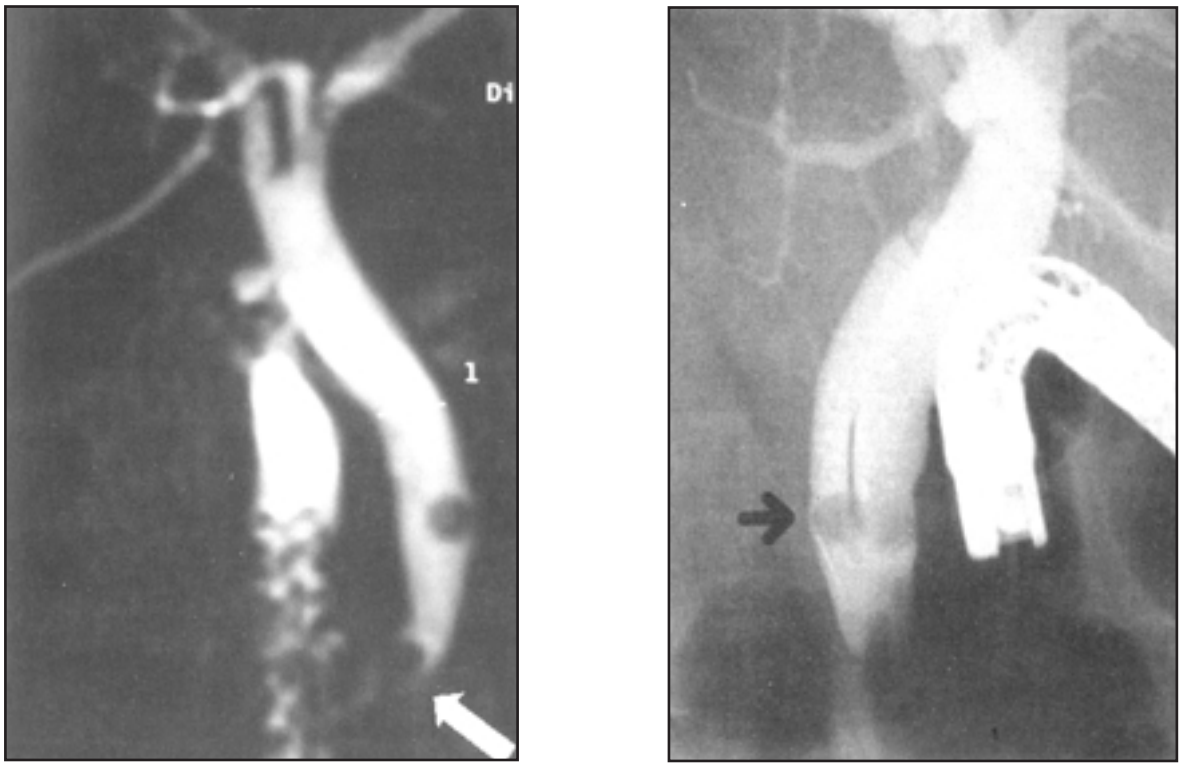
RESULTS

Choledocholithiasis

0n the basis of the final diagnosis, 28 patients had choledocholithiasis. MR cholangiography correctly diagnosed 27 of 28 cases of choledocholithiasis (Table 1). Calculi were associated with mild or distinct bile duct dilatation in 23 cases and with nondilated bile ducts in four cases. One case of failure to diagnose by MR cholangiography was of stones < 2 mm, diagnosed by ERCP. Of the 40 cases without choledocholithiasis, MR cholangiography made false diagnosis of choledocholithiasis (single impacted stone) in only one case where the final diagnosis was main bile duct adenocarcinoma, suspected on ERCP and confirmed at surgery. MR cholangiography had a sensitivity of 96%, a specificity of 97%, a positive predictive value of 96%, a negative predictive value of 98% and an accuracy of 97%, in the diagnosis of choledocholithiasis (Table 2).

Bile duct stenosis

On the basis of the final diagnoses, 32 patients had stenosis, causes of stenoses being benign in 15



A B

Figure 1. True-positive MR cholangiographic diagnosis of choledocholithiasis. (A) Coronal MR cholangiographic sourge image shows two areas of low signal intensity within a dilated CBD. (B) ERCP image confirms the presence of two stones in the distal CBD. The patient underwent cholecystectomy.

patients and malignant in 17 patients. The stenoses were located at the intrahepatic or hilar level in eight patients, the supra-pancreatic portion of the common bile duct in 13 patients and the intra-pancreatic or ampullary level in 11 patients (Table 1). The degree of stenosis was correctly assessed in all cases. One patient with a gastric tumour and one with a colon tumour had bile duct obstruction due to metastases at the hilary level. Both of the patients had previously undergone surgery. In one case, main bile duct carcinoma was misinterpreted as impacted stones. Out of 11 cases of stenoses at the pancreatic and ampullar levels, MR cholangiography could not differentiate the cause of stenosis in three cases. In two patients, MR cholangiography showed stenosis at the ampullar level. In these patients, benign papillary stenosis was subsequently diagnosed with ERCP, and endoscopic sphincterotomy was performed. In one patient, chronic pancreatitis was interpreted as a pancreatic carcinoma confirmed by ERCP and clinical follow-up. In 29 out of 32 patients, MR cholangiograpy differentiated the cause of the stenoses. It had a sensivity of 97%, a specificity of 94%, a positive predictive value of 94%, a negative predictive value of 97% and an accuracy of 96% in the diagnosis of benign and malignant bile duct stenosis (Table 2).

Table 2. Choledocholithiasis and bile duct stenosis: diagnostic value of MR cholangiography in 68 patients

Test parameters	*choledocholithiasis*	*stenosis*
Findings		
True-positive	27	31
True-negative	39	34
False-positive	1	2
False-negative	1	1
Statistical measures		
Sensitivity (%)	96	97
Specificity (%)	98	94
Accuracy (%)	97	96
Positive predictive value (%)	96	94
Negative predictive value (%)	98	97

Figure 2. Coronal images obtained in a patient with a large gallstone. Image shows a large stone (arrow), which is impacted at the ampulla of Vater.

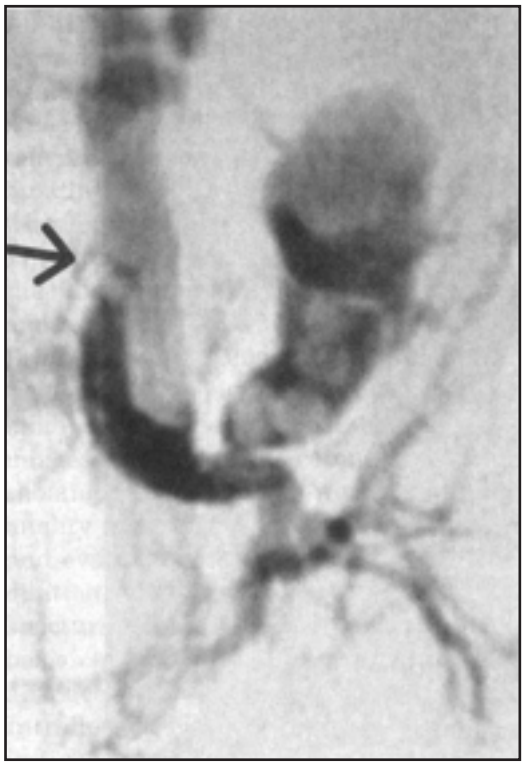


Figure 3. Figure 3. Multiple gallstones and single stone within a dilated CBD.

DISCUSSION

No established non-invasive imaging method is sufficiently reliable to answer the clinically important questions that arise when bile duct disorders are suspected because each imaging method has inherent limitations. Ultrasonography is an operator-dependent method and often fails to demonstrate the distal bile duct (5,6). CT cannot reliably show noncalcified stones (7) and intravenous cholangiography is of limited value with elevated bilirubin levels (8). ERCP is regarded as the diagnostic method of choice for disease of the biliary system. However, diagnostic ERCP is technically unsuccessful in approximately 4% of patients (1) and is associated with a risk of 0.8%-5.0% (1-4) for nonfatal complication such as pancreatitis and cholangitis and of 0.1% for fatal complications (1,4).

In practice, because of the limited sensivity of US and CT and the morbidity associated with ERCP, there is a need for an accurate, non-invasive test that could replace diagnostic ERCP. Computed tomography cholangiography was introduced as a method of indirect cholangiography (9-11). It takes advantage of the high contrast and spatial resolution of helical CT to produce three-dimensional reconstructions of the opacified biliary tree. However, one of the major drawbacks of CT cholangiography is the need to use a contrast medium such as iodipamide meglumine or its derivatives.

Magnetic resonance cholangiography is a recently developed application of MR imaging that yields high-quality cross-sectional and projectional images of the biliary tree and pancreatic duct with the use of heavily T2-weighted sequences. In contrast to US or ERCP, MR cholangiography is neither operator depended nor invasive. In addition, unlike ERCP or CT, the patient undergoing this procedure receives no ionizing radiation or contrast media.

Initial studies of MR cholangiography used non-breath-hold T2-weighed gradient-echo (13) and

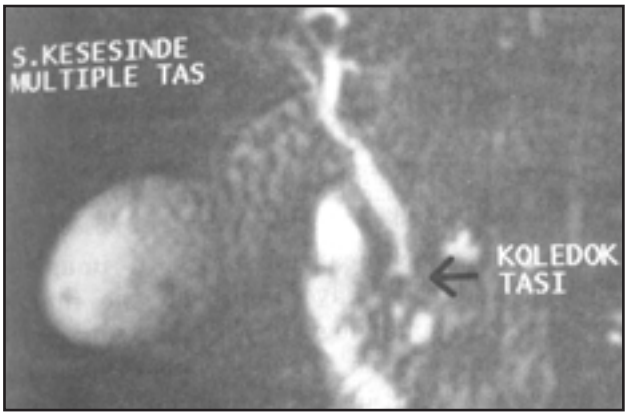


Figure 4. Multiple gallstones and single stone within a nondilated CBD.

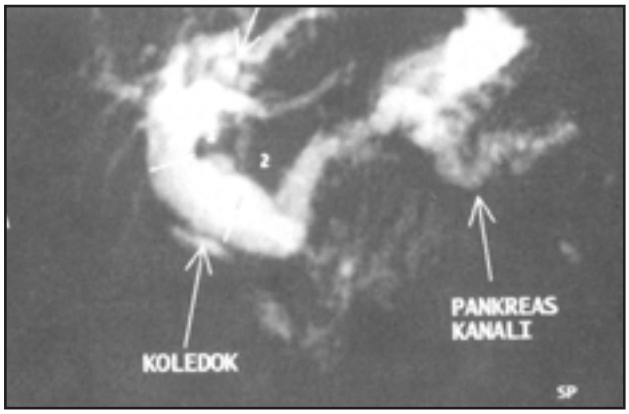


Figure 5. Ampulla of Vater carcinoma. Coronal image shows extremely dilated CBD and pancreatic duct.

two-dimensional (13-14) or three dimensional fast spin-echo (15-17) sequences. Fast spin-echo is generally implemented as a non-breath-hold technique with an acquisition time in the range of several minutes. More recently, the use of breath-hold techniques has become possible with the introduction of single-shot RARE (18) and half-Fourier single-shot RARE (19,20) techniques. With single-shot RARE sequences, imaging time can be reduced to four-five seconds (18). The addition of half-Fourier single-shot acquisition allows even faster imaging (20,21). Several groups of investigators have compared pulse sequences for MR cholangiography and found that the RARE sequences had the highest contrast-to-noise ratio and spatial resolution and that this technique provided the best image quality (20,21).

Results of MR cholangiography in the diagnosis of choledocholithiasis have been reported for the most part in small series of patients. Chan et al (14), compared ERCP with MR cholangiography in 47 patients; 19 patients were found to have choledocholithiasis and the authors obtained a sensivity of 95% and specificity of 85% for diagnosing choledocholithiasis. Varghese et al (22) studied 100 patients with MR cholangiography by using a two-dimensional fast spin echo technique and local surface coil; 30 patients were found to have choledocholithiasis and the authors obtained a sensitivity of 93% and specificity of 99%. Other recent studies have yielded sensitivities of 90%-100% (22-24). Although the specificities reported in these studies have been very high (98%-100%), if MR cholangiography is to replace ERCP as a diagnostic test for choledocholithiasis, the sensivity of this procedure should be equal or superior to the 90% generally reported for ERCP (5). In the present study, choledocholithiasis was detected with a sensitivity of 94 % and a specificity of 98% and these results are comparable with other recent studies. With MR cholangiography, bile duct stenosis was detected with a high sensitivity and specificity (14,23,24) and the level of stenosis was precisely defined in the vast majority of cases. Although MR cholangiography findings showed the level of stenosis in the majority of the cases, the distinction between benign and malignant strictures at the ampullar level could not be determined in approximately one-third of cases; mainly pancreatic carcinoma could not be differentiated from chronic pancreatitis and benign ampullar stenosis could not be differentiated from ampullar carcinoma (17,24). These differentiations, however, were also sometimes difficult to make with ERCP or even at surgery.

Despite the excellent diagnostic capabilities of MR cholangiography, its major limitation compared with ERCP and PTC is its inability to offer therapeutic intervention. In fact, 33 of our 68 patients (49%) required some type of endoscopic intervention: sphincterotomy, stone removal, and stricture stenting. Although MR cholangiography cannot replace ERCP or PTC as a therapeutic manoeuvre, it may significantly decrease the need for purely

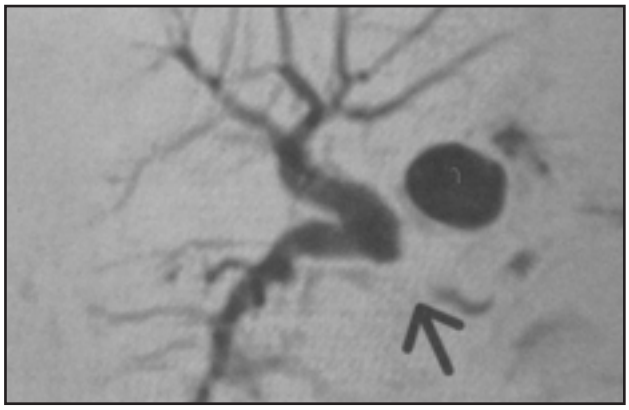


Figure 6. Coronal image of CBD carcinoma and undrained bile duct.

diagnostic ERCP. It may be used as the method for obtaining cholangiographic images in patients with abnormal liver function tests or upper abdominal symptoms of possible biliary origin. The demonstration of a normal bile tract allows avoidance of unnecessary invasive diagnostic tests. Finally, the high sensitivity for diagnosis of choledocholithiasis may make MR cholangiography the ideal method for evaluating patients prior to laparoscopic cholecystectomy.

In conclusion, technical advances in imaging sequences and coils have improved the image quality in MR cholangiography so that this technique has emerged as a non-invasive, accurate alternative to ERCP in the evaluation of the biliary tract diseases. MR cholangiography is particularly useful in the setting of choledocholithiasis, malignant obstruction, failed or incomplete ERCP, intrahepatic bile duct disease, post surgical anatomic alterations and congenital anomalies of the biliary tract. In addition, intentional or incidental imaging of the gallbladder with MR cholangiography can be used to identify calculi or help determine the presence and extent of neoplastic disease.

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