Role of Magnetic Resonance Cholangiopancreatography in Patients With Suspected Choledocholithiasis

MARI M. CALVO, MD, PhD; LUIS BUJANDA, MD, PhD; ANGEL CALDERÓN, MD; ISAKI HERAS, MD; JOSÉ L. CABRIADA, MD; ANTONIO BERNAL, MD; VÍCTOR ORIVE, MD; AND ÁNGEL CAPELASTEGI, MD

From the Department of Gastroenterology (M.M.C., I.H., J.L.C., A.B.) and Department of Radiology (Osatek-RM) (A.C.), Galdakao Hospital, Galdakao, Spain; Department of Gastroenterology, San Eloy Hospital, Baracaldo, Spain (L.B.); and Department of Gastroenterology, Basurto Hospital, Bilbao, Spain (A.C., V.O.).

Presented in part at the Gastroenterology Spanish Association annual meeting; Madrid, Spain; March 2001.

Individual reprints of this article are not available. Address correspondence to Luis Bujanda, MD, PhD, C/Ocharan Mazas, 13 Q-1° A, 39700 Castro Urdiales (Cantabria), Spain (e-mail: digestivo.sanelyog@sanel.osakidetza.net).

Endoscopic retrograde cholangiopancreatography (ERCP) is the reference diagnostic technique for visualizing biliary tract lithiasis. However, the technique is invasive, and the associated morbidity and mortality are considerable. Abdominal ultrasonography is a good exploratory option for visualizing biliary tract morphology, although its etiologic diagnostic sensitivity for the different causes of obstruction is low.

Magnetic resonance cholangiopancreatography (MRCP) is a new technique that provides images similar to those of ERCP but without the need for contrast medium. Magnetic resonance cholangiopancreatography is noninvasive and involves no morbidity, provided its limited indications are observed.

We investigated the diagnostic efficacy of MRCP in patients with suspected choledocholithiasis.

For editorial comment, see page 407.

PATIENTS AND METHODS

A total of 116 patients with suspected pancreaticobiliary diseases (mean age, 67 years; male-female ratio, 1.08:1) were subjected to diagnostic and/or therapeutic ERCP and MRCP over 15 months (November 1996 to February 1998). In all patients, MRCP was performed within 72 hours before ERCP.

The inclusion and exclusion criteria are indicated in Table 1. Initially, 61 patients were suspected of having choledocholithiasis based on clinical and/or laboratory findings and/or a dilated biliary tree visualized by ultrasonography (Cotton criteria, Table 2). A complete cholangiogram was obtained with ERCP in 60 of these patients (with failure in the 61st patient because of cannulation of the papilla due to a lodged duct stone). Magnetic resonance cholangiopancreatography was then used to visualize the biliary system in all 61 patients (Table 2).

The study was approved by the local committee on human research, and all patients gave written informed consent to participation.

CT = computed tomography; ERCP = endoscopic retrograde cholangiopancreatography; HASTE = half-Fourier acquisition single-shot turbo spin echo; MRCP = magnetic resonance cholangiopancreatography
Table 1. **Inclusion and Exclusion Criteria***

**Inclusion criteria**
1. Patients with suspected biliopancreatic pathology requiring ERCP between November 1996 and February 1998
2. Age >18 y
3. All patients in whom ERCP was started were included, even those in whom the pyloroduodenal region was not passed, the papilla could not be cannulated, or the desired therapy was not performed
4. All patients in whom MRCP was started were included, even those in whom exploration could not be completed
5. Informed written consent was required of the patient or relatives for both procedures

**Exclusion criteria**
1. Patients with at least 1 absolute contraindication to either technique
2. Certain patients with degenerative or ankylotic conditions or those with senile dementia, because of the impossibility of patient cooperation in MRCP
3. Patients with severe clinical conditions in whom therapeutic requirements were urgent

*ERCP = endoscopic retrograde cholangiopancreatography; MRCP = magnetic resonance cholangiopancreatography.

**MRCP Technique**

All MRCP images were obtained by using a 1.5-T superconducting magnet with a gradient strength of 20 mT/m (Magnetom Expert, Siemens, Erlangen, Germany), with a body-phased array coil through the liver and pancreas. The mean time of the MRCP examination with evaluation was 15 minutes.

Magnetic resonance cholangiopancreatography was performed by using 2 HASTE sequences (half-Fourier acquisition single-shot turbo spin echo), with selective fat saturation. The first sequence afforded a single image with a dimension of 10 to 80 mm, and it exhibited the following parameters: TR/TE/FA (2800/1100/180), matrix 240 × 256, field of view of 300 mm, and acquisition time of 7 seconds. The second sequence yielded 13 contiguous 5-mm slices and presented the following parameters: TR/TE/FA (10.92/87/180), matrix 240 × 256, field of view of 280 mm, and acquisition time of 19 seconds.

Both sequences were acquired with breath-hold; as a result, adequate patient cooperation was essential. No type of contrast medium or medication was administered, and the patients were instructed to fast for 4 to 6 hours before the examination to prevent gastric contents from producing artifacts.

The slice most suitable for further evaluation was selected. From this slice, we selected right and left oblique coronal (10°-40°) and coronal projections with a HASTE fat-suppressed sequence by using the aforementioned parameters with additional fat suppression. The individual images were examined with maximum intensity projections and multiplanar reconstructions. The HASTE and HASTE fat-suppressed modalities were breath-hold volume image acquisition sequences that permit 3-dimensional reconstruction and viewing in multiple planes.

A long echo train was used, and because of the T2 decrease during data acquisition, the low-T2 tissues generated practically no signal; this and the fat saturation virtually suppressed the background signal. Only high-T2 tissues such as static fluids (eg, in the biliary tree) yielded high signal intensities.

The MRCP images were analyzed by radiologists with experience in the field who were informed of the most relevant clinical data and results of other imaging studies performed (eg, ultrasonography). At no time was there any communication between investigators and radiologists.

Table 2. **Initial Classification of Suspected Choledocholithiasis According to Cotton Criteria as Determined by ERCP and MRCP***

<table>
<thead>
<tr>
<th>Cotton criteria</th>
<th>ERCP (No.)</th>
<th>MRCP (No.)</th>
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</thead>
<tbody>
<tr>
<td>Group 3 (high probability)</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>High risk due to cholangitis, pancreatitis, or jaundice;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anomalies in liver tests (more than twice the normal level); and</td>
<td></td>
<td></td>
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<tr>
<td>dilatation of the common biliary duct (&gt;10 mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2 (intermediate probability)</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>History of stone migration (antecedents of cholangitis or biliary pancreatitis),</td>
<td></td>
<td></td>
</tr>
<tr>
<td>anomalies in liver tests (less than twice the normal level), and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>moderate dilatation of the common biliary duct (8-10 mm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 1 (low probability)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Normal hepatic tests, no history of stone migration, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>narrow common biliary duct (≤7 mm on ultrasonography)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ERCP = endoscopic retrograde cholangiopancreatography; MRCP = magnetic resonance cholangiopancreatography.
The radiologists reading the MRCP did not know the results of the ERCP.

**ERCP Technique**

Endoscopic retrograde cholangiopancreatography was considered the reference technique for determining the sensitivity and specificity of MRCP for choledocholithiasis, and it was always performed and interpreted by the same endoscopy team.

Both exploratory techniques were used to assess the size of the biliary and pancreatic tracts, rating them as either normal or dilated, and to determine the presence or absence of obstruction, its level, and the underlying etiology.

Sphincter of Oddi manometry was not performed; consequently, the suspected diagnosis of papillitis or dysfunction of the sphincter of Oddi as determined by ERCP was based on the following parameters: filiform papillary stenosis, delayed contrast medium elimination, and/or pain in response to contrast medium injection.

**Statistical Analysis**

The descriptive study consisted of the calculation of mean and median values, SD, and range. The sensitivity, specificity, and positive and negative predictive values were used to compare the 2 imaging techniques, ie, the performance of MRCP vs that of the gold standard (ERCP). Analysis focused on the comparison of cholangiography and pancreatography as obtained with both techniques.

The $\chi^2$ test was used to compare groups. Statistical significance was set at $P<.05$. The Epi-Info version 6.4 program and the SAS statistical package for Windows (version 6.12) were used throughout.

**RESULTS**

Endoscopic retrograde cholangiopancreatography visualized stones in 32 (65%) of the 49 patients with a high probability of choledocholithiasis (Table 3) and in 3 (33%) of the 9 patients with an intermediate probability of choledocholithiasis (Table 4) (Figures 1, 2, and 3). Cholangiography by ERCP and MRCP was normal in the 2 patients with a low probability of choledocholithiasis.

Magnetic resonance cholangiopancreatography correctly diagnosed the 3 patients with choledocholithiasis in the intermediate-probability group, and in the high-probability group MRCP confirmed 29 of the 32 cases diagnosed by ERCP; ie, there were 3 false-negative readings by MRCP. In 1 patient a firm diagnosis of biliary tract normality was obtained; in another patient a differential diagnosis of aerobilia was considered; and in a third patient, doubts were raised about an obstructive duct stone or an ampullary neoplasm. Choled-

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**Table 3. Comparative Results of ERCP and MRCP in High-Probability Patients (n=49)**

<table>
<thead>
<tr>
<th>Findings</th>
<th>ERCP (No.)</th>
<th>MRCP (No.)</th>
<th>Therapeutic ERCP (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallstones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>32</td>
<td>29</td>
<td>32</td>
</tr>
<tr>
<td>Diagnostic doubt between gallstone and aerobilia</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Diagnostic doubt between gallstone lodged in papilla and ampulloma</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Papillitis</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Diagnostic doubt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ampulloma</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Diagnostic doubt between ampulloma and obstructive choledocholithiasis</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cholangiocarcinoma</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Normal</td>
<td>10</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Diagnostic doubt with aerobilia</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

*ERCP = endoscopic retrograde cholangiopancreatography; MRCP = magnetic resonance cholangiopancreatography.

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**Table 4. Comparative Results of ERCP and MRCP in Intermediate-Probability Patients (n=9)**

<table>
<thead>
<tr>
<th>Findings</th>
<th>ERCP (No.)</th>
<th>MRCP (No.)</th>
<th>Therapeutic ERCP (No.)</th>
</tr>
</thead>
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<tr>
<td>Gallstones</td>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Papillitis</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Diagnostic doubt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

*ERCP = endoscopic retrograde cholangiopancreatography; MRCP = magnetic resonance cholangiopancreatography.
choledocholithiasis was confirmed by ERCP in this last-mentioned patient. Two false-positive findings were recorded involving normal ERCP results in the presence of uncertainty between aerobilia and choledocholithiasis by MRCP.

Another patient had filling defects at the ampullary level with a differential diagnosis of ampullary neoplasm or obstructive choledocholithiasis (ERCP confirmed an ampullary neoplasm). Another false-positive result with MRCP was classified as papillary dysfunction by the reference technique.

Overall, MRCP had a sensitivity of 91%, a specificity of 84%, a positive predictive value of 89%, a negative predictive value of 88%, and a diagnostic accuracy of 90% in the diagnosis of choledocholithiasis.

The level of duct obstruction was clearly visualized in all patients, with a good correlation to ERCP. In 1 patient both techniques identified a stone at the bifurcation of the hepatic ducts, together with a case of Mirizzi syndrome. In the rest of the patients the stone was located at middle or distal duct level. In no patient was intrahepatic lithiasis detected. Suprastenotic dilatation was also well correlated to ERCP, and no false-positive or false-negative results were obtained.

Purely diagnostic ERCP was performed in 3 high-probability patients (6%) (Table 3), with interventional measures in the remaining patients; this included some patients with normal ERCP findings at the time, due to the risk of biliary colic, who had spontaneous stone elimination. In the intermediate-probability group (Table 4), purely diagnostic ERCP was performed in 2 patients (22%), and in the low-probability group the technique was strictly exploratory in both patients.

Morbidity was 4% (2 of 49 patients) and consisted of mild acute pancreatitis and digestive tract bleeding sec-
Choice of therapy that required endoscopic sclerotherapy. Purely diagnostic ERCP caused no morbidity. Mortality was zero.

**DISCUSSION**

Choledocholithiasis is the most common cause of biliary tract obstruction. Approximately 15% of patients with choledocholithiasis present with stones in the duct. Choledolithiasis may occasionally cause complications in the form of cholangitis, liver abscesses, pancreatitis, or biliary cirrhosis. Thus, establishing a correct diagnosis is extremely important before any form of therapy is attempted.

With the introduction of computed tomography (CT) and ultrasonography, both oral and intravenous cholangiography have been relegated to a secondary role or simply are not performed. However, neither CT nor ultrasonography is effective in exploring the distal duct or ampullary region. In this context, the sensitivity of ultrasonography and CT in the diagnosis of choledocholithiasis is about 38% to 65% and 60% to 85%, respectively. The development of ERCP was a turning point in the management of such patients. This technique performs direct cholangiography and pancreatography, and it allows diagnosis, treatment, and/or palliative measures in the same procedure. Currently considered the reference technique in biliary and pancreatic pathology, ERCP affords a high diagnostic sensitivity. However, it has complications. The associated morbidity has been estimated to be around 0.8% to 10% (pancreatitis, perforation, hemorrhage, or cholangitis). Moreover, analgesia is required, and the technique is operator dependent. In this context, cannulation failure is reported in up to 3% to 9% of cases, even in experienced hands.

Magnetic resonance cholangiopancreatography provides images similar to those of ERCP but without the need for contrast medium of any kind. Thus, MRCP is considered a noninvasive technique that requires no patient sedation and is less operator dependent than ERCP. It provides images or sections in all 3 spatial dimensions. However, in some patients with claustrophobia it is necessary to administer sedation before MRCP is performed. Also, to obtain high-quality images with MRCP, patients must observe strict breath-holding. As a result, patients who have an altered mental status or are too ill may be unable to undergo MRCP.

In the present study, the global efficacy of MRCP in diagnosing choledocholithiasis was high (90%) and similar to the results obtained by other authors (Table 5). In the study by Zidi et al, the sensitivity was low (57%). However, this may be because half the patients with choledocholithiasis had small stones and the patients fasted before MRCP. The main source of false-positive and false-negative results was the differential diagnosis of choledocholithiasis or aerobilia. Determination of the cause of signal voids within hyperintense bile was difficult with MRCP. By means of axial acquisitions, MRCP can attempt to distinguish between aerobilia and lithiasis because air bubbles are located in the upper portion of the duct, whereas stones tend to settle. In such situations, ERCP offers the advantage over MRCP by being able to perform tract cleaning or sweeps with balloons, verifying the diagnosis of lithiasis if stones are extracted. Other differential diagnoses (in addition to choledocholithiasis and aerobilia) that should be considered in the presence of signal voids in the biliary tract are hemobilia and intraductal tumors. In our study there were 2 false-positive MRCPs (ERCP was normal). It is possible that the stones present at the time of MRCP were spontaneously passed during the lapse (<72 hours) before ERCP was performed.

Another difficult situation for MRCP is the differential diagnosis between a stone lodged in the papilla and ampullary neoplasm, which occurred in 2 of our patients. The ERCP interpretations in these cases were a papillary tumor in 1 patient and obstructive choledocholithiasis in the other.

Another source of false-negative MRCP readings is very small stones, eg, impacted calculi (not surrounded by bile) and stones smaller than 3 to 5 mm.

One of the patients endoscopically diagnosed with papillary stenosis was identified as having choledocholithiasis by MRCP. A retrospective evaluation suggested that this false-positive result may have been a “pseudo-calculus sign” due to retrograde sphincter contraction with invagination of the proximal portion.

Of the 50 patients considered to have a high probability of choledocholithiasis, ERCP found a stone in the biliary tract in 65.3%. These results agree with those of Cotton.
with stones in 50% to 80% of patients. In 3 patients (6%) the exploration was purely diagnostic. Some patients were subjected to papillotomy despite the fact that no cholecot-
olithiasis was identified at the time. Therefore, in pa-
tients with a high probability of cholecotolithiasis and who are candidates for interventional measures, ERCP is a good diagnostic/therapeutic option because it is possible to
eliminate the need for MRCP and thus limit costs and
unnecessary delays in treatment. Sahai et al34 re-
ported that MRCP prevented less than 4% of diagnostic and thera-
pic ERCP procedures. In that study, 62.3% had jaundice
or abnormal liver enzymes or high suspicion for structural
disease (high probability according to Cotton criteria), and in
these cases the need for therapeutic ERCP was more
frequent, as it was in our own study. Despite the few
intermediate-probability patients in our study, this group
may benefit from an initial MRCP to avoid purely diag-
nostic ERCP in up to 22% of cases.

Magnetic resonance cholangiopancreatography played
a fundamental role in the diagnosis of patients thought to
have a low probability of cholecotolithiasis, for in most
such situations ERCP failed to detect cholecotolithiasis
despite the limited number of patients involved in our
series. Additionally, MRCP may play an important role in
confirming spontaneous elimination of cholecotolithiasis
after ERCP and sphincterotomy, in suspected choleco-
tholithiasis among patients with previous biliary or gastric
surgery, in subjects with gallbladder in place and amenable
to laparoscopic cholecystectomy, and in patients in whom
ERCP has failed. We have not conducted a cost-efficacy
evaluation of MRCP, although other authors saw an
improved cost-efficacy ratio of MRCP in patients with
intermediate risk of cholecotolithiasis.35

CONCLUSIONS
In our study, MRCP had high diagnostic accuracy in the
evaluation of cholecotolithiasis. In our opinion, MRCP
may replace ERCP in patients with a low or intermediate
probability of cholecotolithiasis based on Cotton criteria.
Patients with a high probability of cholecotolithiasis
should be referred for ERCP. In fact, 46 (94%) of the 49
high-probability patients who underwent ERCP required
some type of endoscopic intervention. This strategy should
reduce unnecessary ERCP without missing pronounced
cholecotolithiasis.

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923.
4. Einstein DM, Lapin SA, Ralls PW, Halls JM. The insensitivity of
sonography in the detection of cholecotolithiasis. AJR Am J
Roentgenol. 1984;142:725-728.

Table 5. Value of MRCP in the Diagnosis of Cholecotolithiasis in Reports by Other Authors

<table>
<thead>
<tr>
<th>Reference</th>
<th>No. of patients with calculi/total</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
<th>Diagnostic accuracy (%)</th>
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<tr>
<td>Taylor et al, 2002</td>
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<td>84</td>
<td>99</td>
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<td>Laokpessi et al, 2001</td>
<td>113/147</td>
<td>93</td>
<td>100</td>
<td>100</td>
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<td>Stiris et al, 2000</td>
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<td>99</td>
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<td>90</td>
</tr>
</tbody>
</table>

*MRCP = magnetic resonance cholangiopancreatography. Ellipses indicate that data not provided in study.


