Comparison of Magnetic Resonance and Endoscopic Retrograde Cholangiopancreatography in Malignant Pancreaticobiliary Obstruction

Steve K. Georgopoulos, MD; Lawrence H. Schwartz, MD; William R. Jarnagin, MD; Hans Gerdes, MD; Ira Breite, MD; Yuman Fong, MD; Leslie H. Blumgart, MD; Robert C. Kurtz, MD

Hypothesis: We hypothesize that magnetic resonance cholangiopancreatography (MRCP) is comparable to endoscopic retrograde cholangiopancreatographic (ERCP) as a diagnostic tool in patients with malignant biliary obstruction.

Design: Eighteen patients with suspected pancreaticobiliary malignancy were evaluated by ERCP and MRCP in 8 months (March 1, 1996, to October 31, 1996). Magnetic resonance cholangiopancreatography was performed with a 1.5-T scanner using 4-mm slices. Images were obtained in a 14- to 28-second breath-hold. Images from MRCP were retrospectively evaluated by a radiologist for image quality, ductal dilation, level of obstruction, and overall diagnostic impression. Images from ERCP were retrospectively evaluated by a biliary endoscopist (L.H.S.) and served as the standard for calculating sensitivity, specificity, and positive predictive values. In addition, intraoperative findings were compared with MRCP results in all patients explored.

Results: Diagnostic-quality MR images were obtained in 18 patients (100%). Diagnostic-quality endoscopic images were obtained in 16 (89%) of 18 attempted biliary cannulations and 11 (78%) of 14 attempted pancreatic cannulations. Magnetic resonance CP accurately delineated the level of extrahepatic biliary ductal obstruction in 13 (87%) of 15 patients. More important, MRCP provided valuable staging information in most patients. Findings from MRCP correlated with operative findings (size and location of tumor and mesenteric vascular involvement) in 8 (80%) of 10 patients who underwent surgery, while failing in 2 patients (20%) with carcinomatosis.

Conclusions: Magnetic resonance CP is a sensitive study for detecting the presence and level of biliary ductal obstruction in patients with cancer. The results are comparable to those of ERCP; however, MRCP provides additional data regarding extent of disease that is not available from ERCP alone.

See Invited Critique at end of article

After its introduction in the 1970s, endoscopic retrograde cholangiopancreatography (ERCP) revolutionized the diagnosis and management of pancreaticobiliary diseases. It remains the gold standard imaging study for visualizing the pancreatic and distal bile ducts. Conversely, ERCP is an invasive, often difficult, operator-dependent procedure that is associated with relatively frequent complications (≤5%). In addition, ERCP provides little if any information regarding the extent of disease, a critical consideration in planning therapy for patients with cancer. To obtain such information, ERCP must be combined with other imaging studies, usually abdominal computed tomographic scanning.

Surgery remains the primary therapy for nearly all pancreaticobiliary cancers. The resectability of these tumors has been notoriously low, however, resulting in many unnecessary explorations. Although laparoscopy has had a major impact in allowing more accurate staging and identification of unresectable disease with less morbidity, patients are not spared the potential risks of general anesthesia and a highly invasive procedure. Noninvasive preoperative imaging that more accurately determines the extent of disease would represent a significant advance.

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Magnetic resonance cholangiopancreatography (MRCP) is a relatively new, noninvasive, non–operator-dependent imaging technique for evaluating pancreaticobiliary diseases. Projectional images similar to direct cholangiograms or pancreatograms are obtained without the use of contrast. In addition to high-quality images of the biliary and pancreatic ducts, MRCP can provide important diagnostic information regarding tumor size and character (solid vs cystic), vascular invasion, or metastatic disease. Since first reported in 1991, modifications in fast MR techniques have improved image quality and have demonstrated high sensitivity and specificity for evaluating a variety of diseases. Whether MRCP will supplant standard imaging studies in patients with malignant biliary obstruction remains an open question.

**RESULTS**

### IMAGE QUALITY

Diagnostic-quality MRCP images were obtained in all 18 patients. In 16 (89%) of 18 patients, ERCP provided adequate cholangiograms but failed in 2 patients (11%) because of difficulty cannulating the bile duct. Successful cannulation and imaging of the pancreatic duct was achieved in 11 (78%) of 14 patients. Three patients were considered technical failures (pancreatic duct could not be cannulated), and cannulation was not attempted in 4 patients. Two ERCP-related complications—pancreatitis (1 patient) and retroperitoneal duodenal perforation (1 patient)—were resolved completely with medical therapy.

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**Table 1. Summary of Patient Diagnoses**

<table>
<thead>
<tr>
<th>Diagnosis</th>
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<tbody>
<tr>
<td>Pancreatic cancer</td>
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<tr>
<td>Ductal adenocarcinoma</td>
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<tr>
<td>Mucinous carcinoma</td>
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</tr>
<tr>
<td>Cystadenocarcinoma</td>
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<tr>
<td>Gallbladder carcinoma</td>
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</tr>
<tr>
<td>Hepatocellular cancer</td>
<td>2</td>
</tr>
<tr>
<td>Hilar cholangiocarcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Ampullary carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Metastatic cancer</td>
<td>1</td>
</tr>
<tr>
<td>Liposarcoma</td>
<td>2</td>
</tr>
<tr>
<td>Adenocarcinoma of the lung</td>
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</tr>
<tr>
<td>Transitional cell</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

**PATIENTS AND METHODS**

**PATIENTS**

The study group comprised 18 patients—7 men and 11 women with a mean age of 66 years (age range, 42-77 years)—with suspected primary or secondary tumors of the distal bile duct or periampullary region seen in 8 months (March 1, 1996, to October 31, 1996). All patients had been evaluated previously with ERCP and subsequently underwent MRCP. Data were collected retrospectively. Malignant obstruction was confirmed by histological examination in 15 (83%) of 18 patients. Two patients with suspected pancreatic cancer had unequivocal radiographic evidence of unresectability, but needle biopsy examination results did not initially confirm the diagnosis. Another patient with an apparent gallbladder carcinoma refused further intervention. Final diagnoses are listed in **Table 1**.

**MRCP TECHNIQUE**

Magnetic resonance CP was performed with a 1.5-T superconducting magnet (Signa; GE Medical Systems, Milwaukee, Wis) and a 4-element torso phased-array coil (GE Medical Systems). Breath-hold (define) MRCP images were obtained using a single-shot fast-spin echo (GE Medical Systems) sequence, with an effective echo time of 105 to 120 milliseconds, 256 × 256 matrix, acquisition time of 18 to 26 seconds, bandwidth of 62.5 kHz, and software versions 5.5 and 5.6 (GE Medical Systems). Images were obtained as contiguous 4-mm-thick sections in the axial and coronal planes, with a field of view of 26 to 40 cm. Field of view and number of sections were tailored to each patient using the minimum required to adequately image the biliary tree. Fat suppression, oxygen inhalation, and antiperistaltic drugs were not used.

**ERCP TECHNIQUE**

A side-viewing electronic duodenoscope (model TJF 100 or JF 100; Olympus Corp of America, Melville, NY) was used. Cannulation of the ampulla was performed in the standard fashion using a Wilson-Cook cannula or cannulotome. Renografin-60 contrast was injected into the desired duct under fluoroscopic control, with subsequent radiographs taken of the ductal anatomic area. When possible, aspiration samples underwent cytologic testing, and duodenal and ampullary abnormalities underwent biopsy examination.

**STATISTICAL ANALYSIS**

Images from MRCP were evaluated by a radiologist (L.H.S.) experienced in pancreatic and biliary tract imaging. Images from ERCP were evaluated by an experienced biliary endoscopist (R.C.K.). All images were reviewed without clinical history or knowledge of the final diagnosis. All studies were evaluated for image quality, ductal dilation, level of obstruction, and overall diagnostic impression. To qualify as an acceptable diagnostic study, all images were required to provide clear visualization of the ducts with adequate resolution. The biliary and pancreatic ducts were subjectively evaluated for the presence or absence of ductal dilation. The ERCP results served as the standard to which MRCP was compared regarding detection, level, and extent of biliary obstruction. Sensitivity, specificity, and positive predictive value were calculated based on this comparison. The overall diagnostic impression based on MRCP findings was compared with that based on ERCP findings. In patients who underwent surgery, MRCP results (extent of disease and vascular invasion) were compared with operative findings.

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Figure 1. A, Endoscopic cholangiogram demonstrating extrinsic compression of the distal common bile duct. The pancreatic duct could not be visualized. B, Magnetic resonance cholangiopancreatogram in the same patient revealed a cystic neoplasm in the head of the pancreas, causing biliary obstruction (small white arrow). A dilated pancreatic duct (small black arrow) and a dilated gallbladder (large white arrow) are also shown.

Figure 2. A, Endoscopic cholangiogram showing a distal common bile duct stricture (arrow). No pancreatogram was obtained. B, Magnetic resonance cholangiopancreatogram in the same patient identifying a mass in the pancreatic head (large white arrow) causing biliary (small black arrow) and pancreatic (large black arrow) ductal obstruction (“double duct sign”). A dilated gallbladder is also shown (small white arrow).

Figure 3. A, Endoscopic retrograde cholangiopancreatogram showing a dilated common bile duct consistent with previous cholecystectomy and a normal pancreatic duct. Slight evidence of an incompletely filled right posterior sectorial hepatic duct (arrow). B, Sagittal magnetic resonance cholangiopancreatographic (MRCP) reconstruction in the same patient revealing a right hepatic lobe mass (small arrow) compressing the right posterior sectorial hepatic duct (large arrow). C, A more anterior MRCP reconstruction further defining the relationship between the mass (large arrow), the right posterior sectorial hepatic duct (small arrow), and the main right hepatic duct (immediately to the left of the tumor).
DUCTAL DILATION

Images from MRCP had slight evidence of pancreatic ductal dilation in 5 patients, 2 of which were thought to be of normal caliber on ERCP (100% sensitivity, 75% specificity, and 60% positive predictive value). In 3 patients who failed endoscopic pancreatography, MRCP demonstrated not only pancreatic ductal dilation but also the underlying cause (Figure 1 and Figure 2). Images from MRCP diagnosed intrahepatic biliary ductal dilation in 14 patients; ERCP confirmed 12 of these (100% sensitivity, 50% specificity, and 77% positive predictive value). In 10 patients, MRCP correctly identified extrahepatic biliary ductal dilation but misdiagnosed 3 of 6 patients with nondilated ducts (100% sensitivity, 50% specificity, and 77% positive predictive value). By contrast, MRCP identified a periampullary mass causing biliary ductal obstruction in 2 patients who failed endoscopic cholangiography. In a third patient with hepatocellular cancer, MRCP demonstrated a mass as the cause of right posterior sectorial hepatic duct obstruction (Figure 3). Also, in 1 patient without ductal dilation on ERCP, MRCP revealed a mass in the uncinate process of the pancreas.

LEVEL OF OBSTRUCTION

Two patients had obstruction of the proximal bile ducts. In 13 (87%) of 15 patients, MRCP correctly identified the level of biliary ductal obstruction compared with ERCP findings: 12 (92%) of 13 patients with mid-distal obstruction (92% sensitivity, 67% specificity, and 92% positive predictive value) and 1 (50%) of 2 with proximal obstruction (50% sensitivity, 100% specificity, and 100% positive predictive value).

EXTENT OF DISEASE AND ASSESSMENT OF RESECTABILITY

Correlation of MRCP results with operative findings was possible in 10 patients (Table 2), 3 of whom had clearly unresectable disease but underwent palliative procedures. Seven patients had apparently resectable tumors: 5 subsequently underwent complete resection and 2 had carcinomatosis and therefore did not undergo resection. Overall, MRCP correctly predicted

<table>
<thead>
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<th>Procedure</th>
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<th>Finding</th>
<th>Patients, No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palliative</td>
<td>3</td>
<td>Superior mesenteric artery/ceeliac sheet encasement</td>
<td>3</td>
</tr>
<tr>
<td>Curative</td>
<td>5</td>
<td>Metastatic disease</td>
<td>4</td>
</tr>
<tr>
<td>Complete resections</td>
<td>2</td>
<td>Refused surgery</td>
<td>1</td>
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<tr>
<td>Unresectable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(carcinomatosis)</td>
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</table>

Table 2. Disposition of 18 Patients Based on Preoperative Investigations

Figure 4. Magnetic resonance cholangiopancreatogram showing pancreatic adenocarcinoma clear of (A and B) and invading (C and D) the mesenteric vessels. A. Gadolinium-enhanced T1-weighted image showing a pancreatic tumor (small arrow) and a clear, uninvolved tissue plane around the adjacent superior mesenteric vein and artery (large arrow). B. T2-weighted image at the same level again showing the mass (white arrow) clear of the superior mesenteric artery and vein (black arrow). C. T2-weighted image demonstrating the tumor (small arrow) encasing the superior mesenteric artery (large arrow). D. Gadolinium-enhanced T1-weighted image at the same level again showing tumor encasement of the superior mesenteric artery (arrow).
the extent of disease in 8 (80%) of 10 patients. Intraoperative assessment of hilar or mesenteric vascular involvement by tumor was performed in 6 patients, and MRCP correctly predicted the extent of vascular involvement in 5 patients (invasion in 1 and no invasion in 4) (Figure 4). In 1 patient, tumor adherence to the lateral wall of the portal vein was not noted before surgery.

Two patients had extrinsic compression of the common bile duct by enlarged, tumor-bearing lymph nodes. Whereas ERCP had slight evidence of such a possibility in 1 patient, MRCP demonstrated this finding clearly in both (Figure 5).

**DIAGNOSTIC IMPRESSION**

After reviewing each study, masked reviewers recorded their impressions of the most likely diagnoses. Diagnostic impressions based on MRCP correlated with those from ERCP in 15 (83%) of 18 patients. There was disagreement in 3 patients, only 1 of whom subsequently underwent surgery. Results of ERCP proved more accurate in this case.

**COMMENT**

All study patients had either primary or secondary pancreaticobiliary cancers; as in all patients with cancer, accurate disease staging is essential for planning therapy. In patients with pancreaticobiliary tumors, determining resectability should be the primary initial objective because complete resection remains the only potentially curative therapy.13,14 Assessment for regional lymph nodal and distant metastases is obviously an important consideration. In addition, the relationship between these tumors and major mesenteric and hepatic hilar vessels is a critical determinant of resectability and requires careful evaluation.

The true measure of worth of an imaging study in this patient population lies in its ability to accurately assess the extent of disease and to reliably demonstrate unresectable disease preoperatively. Other factors, such as morbidity to the patient, need for additional studies, and cost must also be considered.

As an emerging technique for imaging the biliary and pancreatic ducts, MRCP must be critically evaluated before standard diagnostic studies are abandoned. Direct comparison of MRCP to established diagnostic methods is an important initial step in this process. Correlation of MRCP results with intraoperative findings, however, will ultimately determine its value.

Results of this study confirm the ability of MRCP to detect biliary and pancreatic ductal dilation with great sensitivity, show that the overall diagnostic impression based on MRCP correlate closely with that of ERCP, and demonstrate the capacity of MRCP to assess disease extent. Ten patients were predicted to have unresectable disease, which was confirmed at surgery in 3 and by needle biopsy examination in 5. Seven patients were predicted to have resectable tumors; 5 underwent complete resection. Furthermore, MRCP provided accurate information regarding the extent of vascular involvement in 5 of 6 patients, failing to detect portal vein adherence in only 1. In 8 of 10 patients who underwent surgery, MRCP correctly predicted the extent of disease. Two cases of carcinomatosis, notoriously difficult to detect before surgery, were missed. Previous studies6-12 of MRCP, although documenting the sensitivity of detecting biliary and pancreatic ductal dilation, have not correlated the results to intraoperative findings.

Thus, MRCP combines accurate images of the biliary and pancreatic ducts and adjacent extraductal structures. The implications are clear. First, many patients might avoid ERCP and its associated morbidity—not only procedure-related complications but also postsurgical complications related to contaminated bile. There is now substantial evidence that preoperative biliary intubation does not improve outcome after surgery15,16 and actually increases the incidence of bile contamination and postoperative complications.17,18 Many of these stents are placed to prevent cholangitis after injecting contrast above a stenotic bile duct, a practice that MRCP may substantially reduce. Second, MRCP, as a single study, may provide all the necessary diagnostic and staging information, sparing patients from undergoing multiple studies.

This study demonstrates the great potential of MRCP and suggests that it will likely evolve into the study-of-choice in evaluating patients with pancreaticobiliary malignancies. However, the small number of patients in this study and others prevents a definitive statement to this effect. A large, prospective study comparing MRCP with standard imaging (ERCP plus computed tomographic scanning), with correlation of both to operative findings, is required. Certainly, MRCP cannot replace the therapeutic applications offered by direct cholangiography. However, by demonstrating unresectable disease and the level of biliary obstruction, MRCP may help direct the appropriate intervention (endoscopic vs percutaneous biliary intubation).

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In the past 3½ decades we have witnessed the introduction of multiple new imaging techniques: endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography, transcutaneous ultrasonography, computed tomography (CT), and, most recently, endoscopic ultrasonography and magnetic resonance cholangiopancreatography (MRCP). All techniques have their proponents, and each has its inherent advantages and limitations. Currently, there seems to be no universally accepted consensus on the imaging procedure of choice in patients with presumed or suspected mechanical biliary obstruction, as either a diagnostic or a staging procedure.

Georgopoulos and colleagues from Memorial Sloan-Kettering Cancer Center, New York, NY, suggest that MRCP might be the optimal diagnostic test (ie, the safest test, with high sensitivity, specificity, and positive predictive value) and should replace ERCP—and I believe they are correct, although this study does not prove it. Results of their preliminary study (only 18 patients) suggest that the noninvasive MRCP is as accurate as the invasive ERCP. This study, however, has several limitations that I am certain the authors would acknowledge. First, small numbers and a wide spectrum of sites of extrahepatic involvement, etc. However, this study, rightfully so with so few patients, does not and cannot pursue this topic. A better study addressing staging is that by Trede and colleagues, who believe that MR is superior to CT in staging pancreatobiliary neoplasms. Further studies with a direct comparison of MR and MRCP with CT (the current gold standard) will be necessary to answer this challenge.

Concerning diagnosis and staging, we as surgeons need to maintain both an open mind and a malleable approach to the evaluation of patients with jaundice; CT, MRCP, staging laparoscopy, and peritoneal cytology all have potential benefits that may change as new procedures become available.

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REFERENCES