From April 1999 to May 2000, 37 patients (19 men and 18 women; mean age, 60.9 ± 16.2 years) with suspected cholelithiasis underwent both magnetic resonance cholangiogram (MRC) and endoscopic retrograde cholangiogram (ERC) examinations. MRC was performed in a few hours before ERC examination. Transverse and coronal images were obtained using heavily T2-weighted turbo spin echo (TSE) and half-Fourier acquisition single-shot turbo spin echo (HASTE) by 1.5T system (Siemens, symphony), with a surface coil centered at upper abdomen.

The final diagnosis was established in 32 patients: ERC (n = 30, ERC failure 7) and intraoperative choledochoscopy (n = 2). As a result of the comparison, using the former two procedures as gold standards, MRC had a sensitivity of 100% and 90%, specificity of 92.86% and 95.45% and the diagnostic accuracy of 96.87% and 93.75% for common file duct (CBD) and intrahepatic duct (IHD) stone groups respectively. Our results showed that MRC was safer and more efficient in demonstrating the location and orientation of bile ducts with stones.

Key words: Magnetic resonance cholangiogram (MRC); Endoscopic retrograde cholangiogram (ERC); Biliary Stone

Methods of noninvasive biliary stone imaging have been intensively investigated, and these efforts have resulted in the development of methods using ultrasonography (US) and computed tomography (CT) for this purpose. Direct cholangiography such as endoscopic retrograde cholangiogram (ERC) or percutaneous transhepatic cholangiography (PTC) is often required to determine the cause and exact location of biliary stones prior to surgery. Magnetic resonance cholangiography (MRC), a new technique for noninvasive imaging of the biliary tract, allows the whole biliary system to be viewed as a projection image on the coronal plane using a three-dimensional post-processing technique. In some institutions, MRC is becoming the initial imaging tool for biliary stone detection, with ERC reserved for therapeutic indications.

The purpose of this study was to determine the reliability and efficacy of both modalities in demonstrating the location and orientation of bile ducts with stones.

MATERIAL AND METHODS

From April 1999 to May 2000, 37 patients (19 men and 18 women; mean age, 60.9 ± 16.2 years) with suspected cholelithiasis underwent MRC and ERC examinations.

All MRC examinations were performed after the patients had fasted for a minimum of 4 hours to promote filling of the gallbladder and gastric emptying. The sequences and signals acquired were obtained either during a breath-hold by those patients capable of holding their breath for 20 seconds or during quiet breathing. No intravenous or oral contrast medium was given except intramuscular injection of anticholinergic agent (Buscopan) for inhibiting gastrointestinal tract peristalsis and orally administered
gas powder to distend the stomach.

MRC imaging was performed with a 1.5 T system (Siemens, Symphony), using a torso coil centered at the upper abdomen of the patient. After a 3-scout-view scanning, survey MR examination of transverse and coronal images were obtained by using heavily T2-weighted turbo spin echo (TSE) and half-Fourier acquisition single-shot turbo spin echo (HASTE). Imaging parameters included the following:

(1) TR/TE/FLIP 5.98/3.0/70 = 5.98 ms/3.0 ms/70 degree (True FISP pulse sequence) matrix: 154x256; thickness: 5 mm; no. of acquisitions: 1; FOV: 300 mm; and scan time: 17 sec.

(2) Heavily T2-weighted turbo spin echo pulse sequence (TSE), single-shot, echo chain=240, 4~6 views used:

TR/TE/FLIP 2800/1100/160 = 2800 ms/1100

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**Figure 1.** Upper abdominal pain, fever and jaundice in a 60-year-old man. **a.** ERC shows normal biliary duct and nonopacification of gallbladder. **b.** True FISP sequence of imaging shows signal void component in the gallbladder (arrowhead) and CBD (small arrow). **c.** True FISP sequence of imaging shows signal void component in the dependent portion of the gallbladder (arrowheads). **d.** MIP MRC (HASTE) heavily T2-weighted source imaging shows gallbladder (black arrowheads) and distal CBD stone (white small arrow) with diverticulum (black small arrow).
ms/160 degree
matrix: 240x256; thickness: 10~40 mm; no. of acquisitions: 1; FOV: 300 mm; and scan time: 4 sec.

(3) HASTE:
TR/TE/FLIP 1300/90/120
matrix: 240x256; thickness: 5 mm; no. of acquisitions: 1; FOV: 300 mm; and scan time: 19 sec.

All source images were reviewed individually at the independent MR console and after either three-dimensional (3D) reconstruction by using a maximum intensity projection (MIP) algorithm or multiplanar projection. The reconstruction of MIP images used version VABE software and required about 1.5 minutes for the entire processing of MRC.

In all patients, the results of MRC in detecting common bile duct (CBD) and intrahepatic duct (IHD) stones were evaluated using subsequent ERC or even intraoperative choledochoscopy as gold standard. ERC was done less than 12 hours after MRC. The ERC was performed using a Toshiba-Kex-804 X-ray fluoroscopic machine. The final diagnosis was established in 32 patients: ERCP (n = 30), ERCP failure: 7/37 and intraoperative choledochoscopy (n = 2).

RESULTS

Of the 32 patients, 18 (56.25%) had CBD stones and 10 (31.25%) had IHD stones on the basis of ERC or surgical findings. For the CBD-stone group, MRC had a sensitivity of 100%, specificity of 92.86% and diagnostic accuracy of 96.87% (Fig. 1b, c, d). The corresponding values for the IHD-stone group were 90, 95.45, and 93.75%, respectively (Figs. 3b-4). Comparing MRC and ERC, the kappa values of those in CBD-stone group and IHD-stone group were 0.932 and 0.85, respectively. Stone size ranged from 2.8 to 21 mm. Of 37 patients who had undergone MRC, 30 patients successfully received ERCP, 7 patient failed, 2 received choledochoscopy.

Comparison of the diagnosis of CBD stones as shown as Table 1.

Sensitivity = \( \frac{18}{18} \times 100\% = 100\% \)
Specificity = \( \frac{13}{14} \times 100\% = 92.86\% \)
Diagnostic accuracy = \( \frac{18+13}{32} \times 100\% = 96.875\% \)

Comparison of the diagnosis of IHD stones as shown as Table 2.

Sensitivity = \( \frac{9}{10} \times 100\% = 90\% \)
Specificity = \( \frac{21}{22} \times 100\% = 94.45\% \)
Diagnostic accuracy = \( \frac{9+21}{32} \times 100\% = 93.75\% \)

DISCUSSION

MRC is a useful adjunctive tool for noninvasive evaluation of patients with biliary tract stones. Compared with ERC, MRC imaging (using the TSE and HASTE sequence) of those patients who can hold their breath for short intervals has provided a good view of the biliary system. In our study, MRC had a high diagnostic accuracy for CBD stones (96.87%) and IHD stones (93.75%), and it was even able to detect stones as small as 2.8 mm.

MRC is comparable in sensitivity to ERC for detection of choledocholithiasis and superior to CT or US. Numerous studies have shown sensitivity of 81~100% and specificities of 85~100% for MRC. Because up to 95% of patients with acute calculous cholecystitis have choledocholithiasis and 10~15% have suspected choledocholithiasis at surgery, MRC may play a role in the preoperative work-up of these patients. However, patients with high clinical suspicion of choledocholithiasis should undergo ERC so that a potential intervention (e.g., sphincterotomy) would not be delayed [1].

ERC remains the test of choice to establish the diagnosis of choledocholithiasis and treatment can be instituted at the same time. It is operator-dependent,

Table 1. Comparison of the diagnosis of CBDs by MRC & reference methods

<table>
<thead>
<tr>
<th></th>
<th>Stone Present (referent methods)</th>
<th>No stones (referent methods)</th>
<th>Total</th>
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<tbody>
<tr>
<td>Stone Present (MRC)</td>
<td>18</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>No Stones (MRC)</td>
<td>0</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>14</td>
<td>32</td>
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</tbody>
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* referent methods = ERC + Surgical operation

Table 2. Comparison of the diagnosis of IHDs by MRC & referent methods

<table>
<thead>
<tr>
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<th>Stone Present (referent methods)</th>
<th>No stones (referent methods)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone Present (MRC)</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>No Stones (MRC)</td>
<td>1</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>22</td>
<td>32</td>
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however, with a success rate in bile duct specification that varies between 90 and 97% [1-6]. In our series, ERC was unsuccessful in 5 (13.5%) of 37 cases. The ERC failure rate may be due to technically difficult or impossible detections in patients who previously underwent biliary surgery (e.g., choledochojejunostomy, Billroth I anastomosis) and drainage procedures for access.

MRC was completely consistent with ERC in showing total opacification, duct dilatation, and stones of the intrahepatic biliary tree. The MRC images were obtained by using the heavily T2-weighted turbo spin echo sequences (Fig. 3a, b, c). ERC, however, is invasive and therefore associated with a morbidity rate of 1~7% and a mortality rate of 0.2~1.0%. Serious complications include contrast allergy, sepsis, bile leak, bleeding, and death. Sepsis is the most common complication, occurring in just less than 20% of the cases [1-5].

The MRC criterion used for the diagnosis of
stones was the presence of a round, oval, or multi-angular signal void in the lining of the extrahepatic bile ducts. The signal intensity of a stone was measured in the darkest area of the stone and compared with the signal intensity of the bile ducts. The size of all stones diagnosed with MRC were measured and their locations were recorded and compared to those seen on other types of images [2].

Criteria for intrahepatic bile duct dilatation were as follows: 1) mild, bile ducts clearly seen; 2) moderate, ducts clearly dilated but identified as individual structures; and 3) severe, massive dilatation with individual ducts difficult to identify [4].

The differential diagnosis of filling defects in the bile ducts most commonly includes stones and air bubbles; however, neoplasms, blood clots, concentrated bile, metallic stents, flow voids, and magnetic susceptibility artifacts from surgical clips must be excluded. Pneumobilia can be differentiated from a calculus by demonstrating a filling defect in the nondependent portion of the bile duct; the filling defect sometimes produces an air-fluid level on axial or sagittal images [1].

Thus, MRC (a) is noninvasive, (b) cheaper, (c) uses no radiation, (d) requires no anesthesia, (e) is less operator-dependent, and (f) allows better visualization of ducts proximal to an obstruction [1-7].

CONCLUSION

It concludes that MRC nowadays plays an important character in the pre-operative work-up. It is becoming an early initial imaging tool for detection of biliary stones, more reliable and safer than ERC. MRC has a higher diagnostic accuracy in detection of CBD and proximal part of IHD stones, so that MRC becomes a first choice of method for screening or diagnosing biliary tract problems.

REFERENCES


Figure 4. Abdominal pain and jaundice in a 56-year-old women. ERC failed. MRC in turbo spin echo heavily T2-weighted imaging shows IHD and CBD stones (white arrows) with very small stones in the distal CBD (arrowhead).
以磁振造影及內視鏡逆行作膽道攝影對膽道結石的診斷

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膽道結石症及閉塞引起的黃疸是胃腸肝膽科門診最常見的疾病之一，因病人的結石是否只侷限於膽囊或膽管，是外科醫師進行膽囊切除術之前很重要的訊息，早期是應用內視鏡逆行性膽道攝影來作為檢查工具之一，因內視鏡逆行性膽道攝影的併發症，如敗血症、出血等，另外病患還要接受放射劑量及施打造影劑，更何況有些病患會產生藥物過敏反應而增加危險性，還有一些因技術上困難而造成檢查失敗。自從磁共振膽道攝影技術發展以後，由於其不具侵襲性，無輻射傷害，及不必施打造影劑而造成危險等優點，使其成為膽道結石症之篩檢技術。

本院自1999年四月至2000年五月共完成37例病例，所有病例均做磁共振及內視鏡逆行性膽道攝影，不過病患在接受內視鏡逆行性膽道攝影數小時前必須先接受磁共振膽道攝影。在統計期間共有30例病例完成內視鏡逆行性膽道攝影檢查，7例失敗，不過有2例從未接受外科手術。經由統計結果我們發現磁共振膽道攝影確實要比內視鏡逆行性膽道攝影更可以清楚診斷出膽道結石數量及大小，因此我們將兩者檢查結果提供給大家參考及指教。

關鍵詞：磁共振膽道攝影，內視鏡逆行性膽道攝影，膽道結石