The role of magnetic resonance cholangiography in the evaluation of biliary anatomy in living liver donors*

Elaine Cristina de Moraes Arruda, Julio Cezar Uili Coelho, Jorge Massayuki Yokochi, Jorge Eduardo Fouto Matias

Abstract

OBJECTIVE: The present study was aimed at evaluating the accuracy of magnetic resonance cholangiography in the assessment of the biliary anatomy in living liver donors in correlation with surgical findings. MATERIALS AND METHODS: Fifty living liver donors were retrospectively evaluated at Hospital de Clínicas da Universidade Federal do Paraná, Curitiba, PR, Brazil. Cholangiographic images were analyzed and results were compared with intraoperative findings. Only anatomical alterations that affected the surgical strategy and had not been previously observed at magnetic resonance cholangiography were considered as being in disagreement. RESULTS: Anatomical variations were found in 7 donors at magnetic resonance cholangiography, and in 14 during surgery. Agreement between imaging and surgical findings was observed in 41 of the 50 patients, and disagreement in 9. Magnetic resonance cholangiography sensitivity, specificity, positive and negative predictive values, and accuracy were respectively 43%, 97%, 86%, 81% and 81.6%. CONCLUSION: Magnetic resonance imaging is a safe and noninvasive method for preoperative evaluation of the biliary tract in living liver donors. However some anatomical abnormalities are not detected by magnetic resonance cholangiography.

Keywords: Liver transplant; Living donors; Magnetic resonance imaging; Biliary tract.

INTRODUCTION

Liver transplant represents the sole treatment possibility for many patients affected by irreversible hepatic diseases, but the scarce offering of organs has been one of the limiting factors in the survival of waiting-list patients with hepatic failure(1).

Living-donor liver transplant is a definite method of treatment introduced for minimizing this problem(2). Particular care should be dedicated to the planning for management of the biliary ducts during liver lobe resection and implantation, considering that the high variability of the biliary anatomy in the population and the pattern of second order biliary branches could change the surgical technique or even represent a contraindication for liver donation(3). Anatomic variants have been described in as many as 19.7%(4) to 43%(5) of individuals. Studies have evidenced the...
utilization of magnetic resonance imaging as the method of choice for preoperative evaluation of the biliary anatomy and also as a sole method for preoperative evaluation in these cases, considering its accuracy in the detection of hepatic parenchyma abnormalities hepatic and lobar volume, besides the depiction of the portal artery, and of the venous and biliary systems anatomy. However, the utilization of this method for this purpose still remains to be more deeply evaluated.

The present study was aimed at retrospectively evaluating the accuracy of magnetic resonance cholangiography (MR cholangiography) for depicting the biliary tract in living liver donors in correlation with intraoperative findings.

MATERIALS AND METHODS

MR cholangiography images and records of all living liver donors were reviewed in the period between November 1998 and May 2006. The present casuistic included 50 donors. All the living donors for liver transplant were included. The individuals with significant vascular or biliary anomalies resulting in contraindication for liver donation were excluded because of the increased risk for postoperative complications. Also, one donor whose records had not been found was excluded. The present study was approved by the Committee for Ethics in Research in Humans of the Institution (Register No. CEP/HC 759.178/2003-11).

The studies were performed in a Gyroscan ACS15 model system (Philips Medical Systems; Best, The Nederlands), with 1.5 T magnetic field and body coil.

The examination protocol included the following sequences:

- Axial, coronal and sagittal, turbo field echo, T1-weighted sequences, adopting the following parameters: 11/4 msec repetition time (TR)/echo time (TE); flip angle = 25°.
- Axial turbo spin echo (TSE) T2-weighted sequence for evaluating the liver (TR/TE: 1,800/160 msec; thickness: 8 mm; gap: 0.8; matrix: 256 × 205 reconstructed for 512 × 410; field of view (FOV): ranging between 300 mm and 380 mm, according to the patient; number of signal averaged (NSA): 4; number of sections: 24).

- Coronal, with overcontinuous slices, 1.5 mm overlapping, with inversion recovery technique for fat suppression, T2-weighted STIR (TSE) for evaluating the biliary tract (TR/TE: 1,800/500 msec; FOV: 230 mm; inversion time: 160 msec; matrix: 256 × 179; NSA: 2; thickness: 3 mm; number of sections: 65 to 80).

The sequences were acquired with respiratory gating mode, and the total examination time ranged between 30 and 50 minutes, depending on the patient’s respiration regularity. Immediately after acquisition, the images were reconstructed and transmitted to the console for processing. The biliary tract anatomy was reviewed on the images acquired and based on maximum-intensity-projection reconstruction. The images were reviewed both in workstations and hardcopies. All the images were reviewed by a same specialized radiologist, with about ten years experience in the interpretation of abdominal images.

The analysis included an evaluation of any variations, particularly those involving the presence of segmental ducts of the right and left lobes, or even the presence of common hepatic duct trifurcation, and the evaluation of the choledocal duct and its main branches.

The extrahepatic biliary tract was considered as being in disagreement. Only those anatomical alterations that affected the surgical strategy and had not been previously observed at magnetic resonance cholangiography were considered as being in disagreement.

RESULTS

Six of the 50 cases involved pediatric liver transplants (recipients with <18 years of age) and 44, adult liver transplants. The donors ranged in age from 18 to 60 years (mean = 32.4 years). Thirty-one patients (62%) were male, with mean age of 30.8 years. Female patients were 19 (38%), with mean age of 35.2 years. Three types of grafts were utilized as follows: Couinaud segments II and III (lateral left segmentectomy) in two cases; Couinaud segments II, III and IV (left lobectomy) in one case; and Couinaud segments V, VI, VII and VIII (right lobectomy) in 47 cases. Anatomical alterations which affected the surgical strategy were found in only two right-lobe donors.

Normal hepatic anatomy could be found by MR cholangiography in 43 patients, and anatomical alterations were found in seven (14%). Three donors (6%) presented junction of the right anterior and posterior he-

Figure 1. MR cholangiography demonstrating a normal hepatic anatomy. A, right anterior hepatic duct; B, right posterior hepatic duct; C, right hepatic duct; D, left hepatic duct; E, common hepatic duct.
MR cholangiography in the evaluation of biliary anatomy in living liver donors

Intraoperative findings corresponding to biliary tract alterations were described in 14 donors (28%). Three patients (6%) presented common hepatic duct trifurcation; three (6%) presented right hepatic duct duplication; and two patients (4%), right hepatic triplication, one of these patients with also an accessory duct. In one donor (2%), a fine accessory bile duct originating from the right posterior duct was observed. Five donors (10%) presented an accessory right hepatic duct, one of them with the accessory duct tributary of the left hepatic duct, another with the accessory duct draining into the choledocal duct, and another with two cystic ducts besides the accessory hepatic duct.

In the analysis of the 50 donors, 34 presented normal anatomy at the surgery, in agreement with the findings at MR cholangiography. Anatomical variations were found at MR cholangiography in seven donors (14%), and in 14 donors (28%) during surgery. These variations were found in two cases with right hepatic ducts, three with triplication of right hepatic duct, one case of common hepatic duct trifurcation, and four cases with accessory hepatic duct. In one of these donors, the accessory duct was tributary of the choledocal duct, in another, of the left hepatic duct, and another with the presence of two cystic ducts. In one donor who had a very small accessory duct that was linked during the surgery, this finding was not considered as being in disagreement. In two patients (4%) anatomical variations were found at MR cholangiography, but intraoperative findings demonstrated a normal anatomy. In one donor, the right anterior and posterior ducts drained separately into the left hepatic duct, and in another case, non relevant from the surgical point of view, a physiological narrowing was described at the level of the hepatic ducts junction (also this case was not considered as being in disagreement).

Among the seven studies with biliary tract abnormalities, five presented results in agreement with the intraoperative findings, two of them with common hepatic duct trifurcation, and one with the right posterior hepatic ducts draining into the left hepatic ducts (the latter demonstrating an accessory duct draining to the left hepatic duct at surgery, interpreted as being in agreement, considering its non-relevance from the surgical point of view). In two donors, the MR cholangiography demonstrated anatomic alterations which although not properly corresponding to the intraoperative findings, neither resulted in change of the surgical strategy nor in the planned anastomotic changes. In one of these donors, MR cholangiography demonstrated trifurcation, but two right hepatic ducts were present, and in the other with an accessory hepatic duct, it was interpreted as a biliary duct of the segment IV. The comparison between MR cholangiography and intraoperative findings is shown on Chart 1.

Therefore, 41/50 donors (82%) presented correspondence between imaging and intraoperative findings, and 9/50 (18%) did not. The MR cholangiography sensitivity was 43%, specificity, 97%, positive predictive value, 86%, negative predictive value, 81%, and accuracy, 81.6%.

DISCUSSION

Living-donor liver transplant is a definite method of treatment for patients with irreversible hepatic diseases, particularly in countries where cadaver liver donors are scarce or even non-existent. In Brazil, the number of living liver donors increased 10% in 2005, and in 2006 remained
stable\(^{(13)}\). The safety of the donors is extremely important, considering that they are healthy individuals submitted to an extensive surgical procedure. So, the detection of the biliary tract anatomy is crucial for allowing the surgical planning and avoiding unnecessary surgery in donors with anatomical variations, besides preventing possible postoperative complications both for liver donors and recipients\(^{(7)}\). According to Liu et al.\(^{(14)}\), biliary complications remain as the most noticeable weakness in living-donor liver transplant, playing a significant role in the occurrence of postoperative morbidities occasionally caused by graft loss. According to Marcos et al.\(^{(15)}\), biliary reconstruction corresponds to the most challenging part of the surgery in the liver recipient, considering that double or triple anastomosis certainly represents a risk factor for biliary complications\(^{(16)}\).

Biliary anatomical variations which lack pathological meaning in the general population, assume a greater relevance in the living-donor liver transplant, playing a significant role in the occurrence of postoperative complications. As previously reported by Lee et al.\(^{(21)}\), the rate of complications from retrograde endoscopic cholangiography ranges between 0.5% and 5%, and from percutaneous transhepatic cholangiography, 3.4%\(^{(17)}\).

Recently, some studies reported magnetic resonance imaging as the sole preoperative method for evaluating living liver donor candidates, demonstrating good results in the evaluation of the biliary tract\(^{(9,11,18)}\). This assumption is based on the fact that conventional MR cholangiography T2-weighted sequences demonstrate high signal intensity from static fluid structures while the background signal is suppressed\(^{(19)}\). On the other hand, there is a difficulty in the evaluation of a non-dilated biliary tract\(^{(3,19)}\). Innovations such as the utilization of a biliary contrast agent (mangafodipir trisodium) have allowed the acquisition of higher resolution images, with good results because of the better enhancement of the biliary tract and higher differentiation from the hepatic parenchyma and from the vascular system\(^{(7,8,20,21)}\). Ayuso et al. have observed a sensitivity of 93.7% and specificity of 100%\(^{(22)}\). However, high cost, limited contrast agent availability, possibility of allergic reactions and increased images acquisition time constitute limiting factor for the utilization of this method\(^{(21)}\).

Other authors have compared contrast-enhanced (gadobenate dimeglumine – Gd-DTPA) MR cholangiography T1-weighted sequences with findings at conventional MR cholangiography T2-weighted sequences and there was a preponderance for contrast-enhanced MR cholangiography in the evaluation of the biliary tract\(^{(23,24)}\). This contrast agent combines the properties of a gadolinium-based extracellular contrast agent as a hepatocyte-direct excreted at about 2%–4% through the biliary tract. An et al\(^{(25)}\) have described an accuracy of 75% with MR cholangiography T2-weighted sequences, 79% with paramagnetic contrast-enhanced T1-weighted sequences, and an increase to 92% in accuracy with the evaluation by means of a combination of both methods.

The results of the present study, likewise those previously reported by Lee et al.\(^{(9)}\) reflect a diligent analysis in relation to the consistency of MR cholangiography for appropriately visualizing the biliary anatomy in liver donors. The present study could demonstrate that MR cholangiography presents a good reproducibility in relation to the surgical findings. However, the low sensitivity of the method and the failure in detecting anatomical variations in nine cases (18%), among them, the presence of common hepatic duct trifurcation, duplicated or triplicated right hepatic ducts and accessory hepatic ducts, inspires prudence and demonstrates that the segmental ducts definition is not clear. As previously reported, the utilization of MR cholangiography with specific contrast agents for studying the biliary tract, as well as further investigation about the utilization of paramagnetic contrast agents such as

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**Chart 1** Comparison between MR cholangiography and intraoperative findings.

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>Findings at MR cholangiography</th>
<th>Findings at surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 (9 and 44)</td>
<td>Normal</td>
<td>Two right hepatic ducts</td>
</tr>
<tr>
<td>2 (15 and 48)</td>
<td>Normal</td>
<td>Three right hepatic ducts</td>
</tr>
<tr>
<td>2 (21 and 34)</td>
<td>Normal</td>
<td>Right accessory hepatic duct</td>
</tr>
<tr>
<td>1 (23)</td>
<td>Right anterior hepatic duct and posterior hepatic duct draining separately to the left hepatic duct</td>
<td>Normal</td>
</tr>
<tr>
<td>1 (29)</td>
<td>Physiological narrowing at the level of the hepatic ducts junction</td>
<td>Normal</td>
</tr>
<tr>
<td>2 (36 and 47)</td>
<td>Trifurcation of the common hepatic duct</td>
<td>Trifurcation of the common hepatic duct</td>
</tr>
<tr>
<td>1 (38)</td>
<td>Right posterior hepatic duct draining to the left hepatic duct</td>
<td>Right accessory hepatic duct draining to the left hepatic duct</td>
</tr>
<tr>
<td>2 (40 and 42)</td>
<td>Normal</td>
<td>Right accessory hepatic duct draining to the choledocal duct and another coursing with two cystic ducts</td>
</tr>
<tr>
<td>1 (43)</td>
<td>Trifurcation of the common hepatic duct</td>
<td>Two right hepatic ducts</td>
</tr>
<tr>
<td>1 (45)</td>
<td>Normal</td>
<td>Trifurcation of the common hepatic duct</td>
</tr>
<tr>
<td>1 (46)</td>
<td>Segment IV bile duct draining to the left hepatic duct</td>
<td>Accessory hepatic duct (segment VI)</td>
</tr>
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gadobenate dimeglumine have contributed for improvement of the method. Recently, single-shot fast spin echo sequences were adopted as a standard method for MR cholangiography\(^\text{[26]}\), and new sequences such as half Fourier RARE have demonstrated technical advances, allowing imaging of the whole biliary tract during a single 18-second breath-hold\(^\text{[27]}\). Maybe the utilization of the described sequences, if available, could result in better images as those already reported by some authors\(^\text{[8,10]}\). Further studies are required to evaluate technological developments such as new sequences and utilization of paramagnetic and biliary contrast agents.

Considering the retrospective character of the present study, the authors could not determine the number of patients excluded as well as the identified anatomical variations.

It can be concluded that MR cholangiography performed with T2-weighted sequences presented a high accuracy, high specificity and low sensitivity. MRI is a safe and non-invasive method with potential capacity and applicability in the preoperative evaluation of the biliary tract in living liver donors. Continued technical innovations will certainly allow an expansion of the utilization of this method in a near future.

REFERENCES