Biliary tract variants in potential right lobe living donors for liver transplantation: Evaluation with MR cholangiopancreatography (MRCP)

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Abstract Living donor liver transplantation is increasingly being used to help compensate for the increasing shortage of cadaveric liver grafts. However, the extreme variability of the hepatic vascular and biliary systems can impede this surgical procedure. The aim of the study is to demonstrate the role of MR cholangiopancreatography (MRCP) in the evaluation of anatomical biliary variants in potential living donors for liver transplantation.

Methods: The study included 20 liver donors in pre-operative assessment before liver transplantation. MR cholangiopancreatography (MRCP) was performed for all donors.

Results: The study included 20 donors (16 men and 4 women) ranging in age from 29 to 52 years. 16 (80%) donors demonstrate normal biliary branching anatomy. One donor has trifurcation biliary branching pattern (5%). Two donors have their right posterior ducts draining into the left hepatic duct (10%). One donor has low insertion of the right posterior duct into the main duct (5%).

Conclusion: MR cholangiopancreatography (MRCP) provides important information in evaluation of potential living donors for liver transplantation.

1. Introduction

Owing to the shortage of cadaveric livers for transplantation, patients and physicians are increasingly turning to living related liver donation (1).

Preoperative evaluation of living potential liver donors routinely involves imaging of hepatic vasculature with computed tomographic (CT) or magnetic resonance (MR) imaging (2–4).

At several liver transplant centers, physicians also pursue preoperative evaluation of biliary tract anatomy, since variant biliary anatomy is seen in up to 45% of the population (5,6).
The pattern of biliary tract branching can affect the surgical approach and biliary anastomotic technique or preclude liver donation (7).

The standard examination for defining biliary anatomy; diagnostic endoscopic retrograde cholangiography has a major complication rate of 1.4–3.2% (8).

Development of a safer method of evaluating biliary anatomy would be beneficial. Noninvasive evaluation of the biliary tract in living potential liver donors is challenging owing to the small caliber of normal-sized bile ducts, although promising results have been obtained by MR cholangiography (9).

At MR cholangiopancreatography, the bile within the biliary tree is imaged with heavily T2-weighted sequences. The sequences are heavily T2 weighted with the use of long echo times in the range of 300–1000 ms, such that only tissues or fluid with prolonged transverse relaxation time (T2) retain signal. These tissues and fluid are seen as hyperintense structures. The background soft tissues with shorter T2 do not retain significant signal long enough in a sequence with prolonged echo time and are, therefore, suppressed. Blood vessels are not seen, since flowing blood does not produce any signal on these images (10).

With the fast spin-echo (FSE) (turbo spin-echo [TSE]) sequence, a 90° radiofrequency (RF) pulse is followed by a train of 180° RF pulses. The number of 180° pulses is called the echo train length (ETL) or turbo factor. The speed of acquisition increases with an increase in ETL. For the purposes of MR cholangiopancreatography, FSE imaging is performed with a long ETL, repetition time, and echo time (>250 ms) (11). A long ETL is well suited for the type of long echo-time acquisition required for MR cholangiopancreatography. FSE imaging can be performed with a breath hold or with free breathing with the use of respiratory gating or a navigator technique (10).

It can be performed as a two-dimensional (2D) sequence with a slice thickness of 2–7 cm or as a three-dimensional (3D) sequence with thinner sections. The resultant data can then be reconstructed into cholangiographic images with a maximum-intensity-projection (MIP) technique (11).

Fast recovery FSE (FRFSE; GE Medical Systems, Waukesha, Wis), RESTORE (Siemens Medical Solutions, Forchheim, Germany), and driven equilibrium FSE (DRIVE; Philips Medical Systems, Best, The Netherlands) sequences are modified FSE sequences in which a 90° RF pulse is used at the end of the ETL to get the magnetization immediately in longitudinal plane, thereby reducing repetition time (10).

Single-shot FSE (TSE) sequence single-shot FSE (SSFSE, GE Medical Systems), half-Fourier single-shot TSE (HASTE, Siemens), and single-shot TSE (SSTSE, Philips) sequences are FSE sequences in which just more than one half of k-space is filled, thus reducing the scanning time significantly. All of the required k-space lines (phase-encoding steps) are filled in a single repetition time; hence the name “single-shot.” Acquisition times are in seconds, with reasonably good spatial resolution (12).

SSFSE imaging has a higher signal-to-noise ratio (SNR) than does FSE imaging as a result of less motion artifact producing noise (11).

Limitations of SSFSE imaging include image blur induced by long ETLs, flow artifacts, and problems with saturation of adjacent sections. Echo times typically range between 300 and 1000 ms. These sequences can be performed with a breath hold or with respiratory triggering, and good-quality images can be obtained, even with quiet breathing (12).

Fast gradient-echo sequences such as balanced fully refocused steady-state sequences (true fast imaging with steady-state precession, fast imaging employing steady-state acquisition, balanced fast field echo) show the biliary tree well, with excellent SNR and good spatial resolution. These sequences can be performed with a breath hold or with quiet breathing and may show ducts reasonably well when other sequences fail to do so because of motion artifacts. One limitation, however, is the fact that blood vessels are seen as bright structures, which may make it difficult to differentiate them from bile ducts (10).

The classic biliary anatomy appears in about 58% of the population and consists of the right hepatic duct and left hepatic duct draining the right and left lobes of the liver, respectively. The right duct branches into the right posterior hepatic duct, draining posterior segments VI and VII, and the right anterior hepatic duct, draining anterior segments V and VIII. The right posterior duct, which has a horizontal course, usually runs posterior to the right anterior duct, which is more vertically oriented, and fuses with it from a medial approach to constitute a short right hepatic duct. Segmental tributaries draining segments II–IV form the left hepatic duct. The fusion of the right and left hepatic ducts gives rise to the common hepatic duct. The caudate lobe usually drains to the origin of the left hepatic duct, or to the right hepatic duct. The cystic duct usually drains into the lateral aspect of the common hepatic duct below its origin (13).

Biliary complications, occurring in 7–10% of donors, represent the most common cause of morbidity in living donor liver transplantation; they include bile leakage and bile duct stricture. Postoperative bile leakage can occur in different locations, but mainly occurs at the caudate branches in the hilar plate. Bile leakage may also occur at the repair site of the hepatic duct and rarely along the parenchymal transection surface of the liver (14).

It has been demonstrated that detailed preoperative evaluation of biliary anatomic variants with MR cholangiopancreatography is useful for preventing this type of complication, helping the surgeons safely perform hepatectomy in the donor and biliary reconstruction in the recipient (15).

One of the most common bile duct variants, found in 15.6% of cases in one series, is the right posterior hepatic duct draining into the left hepatic duct. This variant can lead to inadvertent biliary tract injury in the donor. Other common clinically relevant anatomic variants of the biliary tract that may complicate transplantation surgery include a posterior–inferior branch of the right hepatic duct draining into the left hepatic duct and biliary trifurcation. In some centers, biliary trifurcation may preclude graft harvesting because of the increase in the postoperative complication rate (13).

It has been demonstrated that accurate pre-surgical assessment of biliary anatomy variants, performed with MR cholangiopancreatography allows surgeons to plan their approach before beginning the procedure and helps prevent biliary tract injuries, resulting in a low biliary complication rate of 1.9% in one series (13).

2. Materials and methods

This study included 20 donors who are preparing for right lobe donation for liver transplantation.
Magnetic resonance cholangiopancreatography (MRCP) was done for the included donors using a 1.5-T closed MR unit (Avanto, Siemens) with a circularly polarized; phased-array body coil was used in all cases.

Antiperistaltic agents and oral contrast material were not used, and the donors did not fast prior to the examination.

All the patients were examined by using half-Fourier rapid acquisition with relaxation enhancement (RARE) MR cholangiographic sequences.

For the 3D sequence, the following parameters are used; (FOV, 380 mm; slice thickness, 2 mm; TR, 1600; TE, 287; NSA, 2).

While in the 2D sequence the parameters used are (FOV, 350 mm; slice thickness, 40 mm; TR, 4500; TE, 792; NSA, 1).

Analysis of the image data was based on source images from the reconstructed data into cholangiographic images with a maximum-intensity-projection (MIP) technique as well as sometimes volume rendering (VR) post processed images created on the available workstation.

3. Results

The study included 20 donors (16 men and 4 women) ranging in age from 29 to 52 years, with their average age (41.2).

Sixteen (80%) donors demonstrate normal biliary branching anatomy (Figs. 1 and 2).

One donor has trifurcation biliary branching pattern (5%) (Fig. 3).

Two donors have their right posterior ducts draining into the left hepatic duct (10%) (Fig. 4).

One donor has low insertion of the right posterior duct into the main duct (5%) (Fig. 5).

4. Discussion

Living donors liver transplantation (LDLT) has become an important therapeutic option for adult patients with the end-stage liver disease. Different series have shown encouraging results, reporting 1-year graft and patient survival rates of up to 80% (16–19).

Fig. 1 Classic hilar biliary branching pattern. MRCP oblique coronal thick-slab HASTE showing the common duct bifurcates (arrow) into right and left main branches. There is excellent visualization of the second order branches.

Fig. 2 Classic hilar biliary branching pattern. Colored volume rendering (VR) post processed image created on the workstation showing the common duct bifurcates (arrow) into right and left main branches.

Fig. 3 Trifurcation hilar biliary branching pattern. MRCP oblique coronal thick-slab HASTE showing the trifurcation branching pattern of the common duct (arrow).

Nevertheless, LDLT is a challenging surgical procedure in which donor safety must be paramount. Biliary complications are the leading cause of postoperative complications after LDLT and are present in up to 30–50% of patients (20).

Accurate preoperative radiologic imaging is essential to assess the vascular and biliary anatomies of a living donor candidate. A correct understanding of a donor’s biliary anatomy is crucial for safe donor hepatectomy and to minimize recipient biliary complications (21).

MRCP has potential as a noninvasive, non-hazardous diagnostic technique for evaluating LDLT donors. However, some limitations compromise the diagnostic potential of MRCP. Among these, respiratory motion significantly influences image
quality. Breath-hold imaging effectively eliminates respiratory motion artifacts. Nevertheless, some patients are unable to hold their breath sufficiently. Spatial resolution can be improved in a longer acquisition time (22).

The breath-hold technique has a relatively short acquisition time; image quality is hampered by a low signal-to-noise ratio and low spatial resolution. The respiratory triggered technique offers the possibility of extending the acquisition time, which can be invested into a higher spatial resolution (22).

In our study 80% of the donors demonstrate classic branching pattern of the biliary radicles.

In a study done by Basaran et al., 67.5% of the donors had classic biliary branching pattern (22).

While Wang et al. showed 56% of their donors had classic branching pattern (23).

Five percentages of the donors in our study demonstrate trifurcation biliary branching pattern.

In the study done by Basaran et al., 5% of the donors had trifurcation pattern of biliary branching pattern (22).

Wang et al., show 11% of their donors having trifurcation pattern (23).

In 10% of the donors in our study, the right posterior duct joins into the left hepatic duct.

Basaran et al. show 20% of their donors having the right posterior duct joining into the left hepatic duct (22).

Wang et al., show 18% of the donors having their right posterior duct into the left duct (23).

In our study a low insertion of the right posterior duct into the main duct is seen in (5%) of the donors.

In the study done by Basaran et al., 2.5% of the donors having their right posterior duct into the main duct (22).

Wang et al., show 8% of the donors having their right posterior duct into the main duct (23).

Wang et al., show 2% of the donors having right anterior duct joining common hepatic duct (23). In our study this variant was not seen.

5. Conclusion

MR cholangiopancreatography (MRCP) provides important information in the evaluation of potential living donors for liver transplantation. It plays a relevant role, providing, with a non invasive procedure, valuable information that will be useful in choosing the most suitable candidate and in identifying anatomic biliary variants that may alter the surgical approach.

References


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