Stratifying Risk of Biliary Complications in Adult Living Donor Liver Transplantation by Magnetic Resonance Cholangiography

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Background. Accurate preoperative assessment of biliary anatomy in live donor hepatectomy may be helpful to assess the suitability of a graft and to stratify risk of biliary complications.

Methods. A retrospective review of existing data among donor and recipients of 36 living donor transplants was performed to assess role of preoperative magnetic resonance cholangiography (MRC) for defining biliary anatomy and to stratify risk of biliary complications.

Results. Thirty-six living liver donors underwent MRC, and subsequently right lobectomy. Intraoperative cholangiography and biliary exploration revealed that 24 donors (66.6%) had conventional and 12 (33.3%) had aberrant biliary anatomy. Intraoperative cholangiography demonstrated a strong correlation with MRC ($P=0.001$) and intraoperative findings ($P=0.001$). MRC had specificity and positive predictive value of 100%. The risk of developing biliary complication was 5.9 times higher if the biliary anatomy was of any type other than A ($P=0.03$, CI 1.06–32.9) after controlling for donor age, recipient age, and type of anastomosis.

Conclusion. MRC reliably identified variant biliary anatomy. The preoperative MRC demonstrated congruence with the intraoperative cholangiogram and with the intraoperative findings. MRC is helpful in predicting risk of biliary complications in recipients, and identifies donors who would otherwise be excluded intraoperatively by cholangiography, thus limiting the risk of an unnecessary operation.

Keywords: Living donor, Biliary complications, Magnetic resonance cholangiography.

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Adult to adult living donor liver transplantation (LDLT) with a right hepatic lobe was introduced in 1994 (*1*). Subsequent experience has demonstrated that there is a learning curve to the procedure, however once overcome, LDLT produces outcomes that are similar or superior to whole cadaveric organs (*2*). Despite durable survival, bile duct complications in the allograft recipient remain a significant problem, and are the most important technical cause of morbidity after LDLT (*2*, *3*). These complications result in multiple percutaneous and endoscopic procedures, and reoperation in 26% of recipients (*4*). The type of biliary drainage, whether duct to duct or through a Roux limb seems to have little impact on the rate of complications (*5–7*).

The biliary system is well known for anatomic variability. Aberrant or unexpected anatomical variations may have important implications for complications among the donor and the recipient. To make effective use of liver segments from living donors for transplantation, preoperative imaging is of importance and may be helpful in selecting an appropriate donor and planning for biliary drainage in the recipient. Several approaches and techniques for biliary imaging have been used with intraoperative cholangiography (IOC) the traditional method for mapping the anatomy of the biliary tract. Alternatively, magnetic resonance cholangiography (MRC), helical CT cholangiography, endoscopic retrograde cholangiography, and percutaneous cholangiography have been used to evaluate the biliary tract (*8–10*). However, MRC compared with IOC has the advantage of preoperative delineation of biliary anatomy (*11*).

Accurate preoperative assessment of biliary anatomy in live donor hepatectomy may be helpful to assess the risk of biliary complications imposed on the donor, to determine the suitability of a graft, and to stratify the risk of biliary complications in the recipient. We hypothesized that aberrations in donor biliary anatomy detected during the preoperative evaluation would result in an increased risk of recipient biliary complications and morbidity. A retrospective review of MRC, IOC, and operative findings from living liver donors was conducted to assess the role of preoperative MRC, to define biliary anatomy, and to stratify the risk of biliary complications.

PATIENTS AND METHODS

From April 2004 to June 2006, a cohort of 36 sequential living liver donors underwent right hepatectomy for adult LDLT at the University of Rochester Medical Center. All hepatectomies were performed by a single surgeon. A retrospective review of MRC and IOC's, intraoperative findings, and postoperative biliary complications in recipients of living liver donors was performed. MRC and IOC findings were

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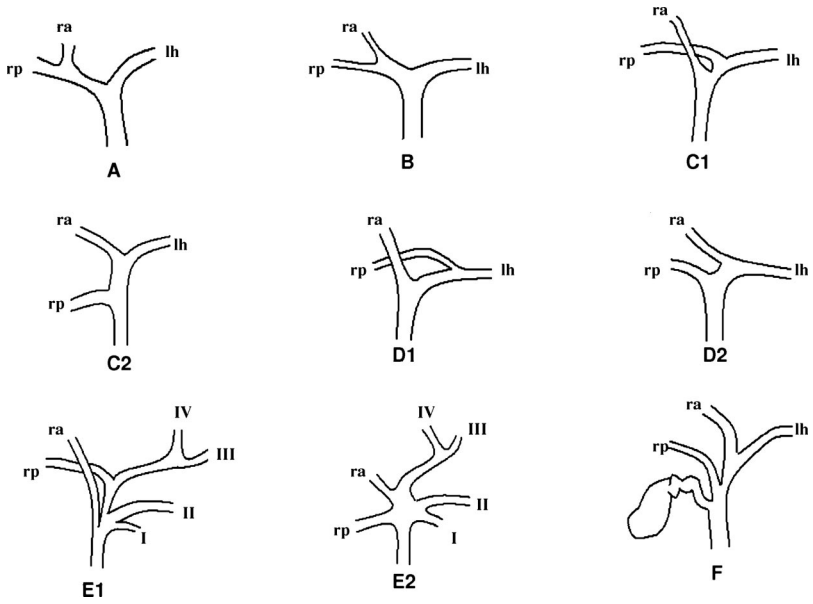

FIGURE 1. MRC and IOC findings classified per Couinaud scheme.

classified per Couinaud schema (Fig. 1). Type A being conventional and any other than type A being aberrant.

Magnetic Resonance Cholangiography

Magnetic Resonance Cholangiography was performed using an 1.5T MR system (Signa Echospeed or Twinspeed with Excite 11.0 or HD, GE Medical Systems, Milwaukee, WI). Thick and thin slab heavily T2 weighted breath-hold images were obtained with a slice thickness of 5 mm, skip 1 mm and 8 mm, skip 2 mm. With the HD system a 3D MRCP protocol was performed with reconstructed images using an IVI technique. Preoperative MRC were blindly interpreted by a radiologist, not aware of the intraoperative findings.

All hepatic resections in donors were performed with cavitronic ultrasound surgical aspirator (valley lab Inc., Boulder, CO), unipolar electrocautery, liga clips, prolene sutures, and silk ties.

Intraoperative Cholangiography

After the gallbladder was dissected off the liver, a 5 F Catheter was advanced through a transverse incision created in the cystic duct. While manually injecting 10 to 20 mL of full-strength iohexol (Omnipaque, Nycomed, Princeton, NJ), fluoroscopy was performed in anterior–posterior and oblique orientations.

In recipient for biliary reconstruction, a duct to duct or a standard Roux-en-y anastomosis was performed. The number and type of the biliary anastomosis were decided according to the anatomy of the ducts. All anastomosis were performed with 6-0 PDS suture in an interrupted fashion over epidural catheter used as a stent.

Statistical Analysis

Means of continuous variables were compared by *t* tests and correlations by Pearson test. Categorical variables were compared by chi-square testing. Odds ratios were calculated using logistic regression. Statistical analysis was performed with SPSS version 13 for Windows (SPSS Inc., Chicago, IL).

RESULTS

Thirty-six living liver donors underwent MRC, and subsequently right lobectomy. The mean age of the 36 donors was 38±11 years; 58.3% were male. Intraoperative cholangiography demonstrated a strong correlation with MRC ($P=0.001$) and intraoperative findings ($P=0.001$). MRC had specificity and positive predictive value of 100%. In three of the patients, there was a discrepancy of which only one (types A and E) was considered surgically significant (Table 1). The discrepancy between the IOC and intraoperative findings in numbers of ducts appearing on the surface is due to the devi-

TABLE 1. Correlation between preoperative imaging and operative findings

	Couinaud classification	IOC A	B	C	D	E	E2	Total	*P*
MRC	A	22	1[a]	0	0	1[a]	0	24	0.001
	B	0	3	0	0	0	0	3	
	C	0	0	4	0	0	0	4	
	D	0	0	0	3	0	0	3	
	E2	0	0	0	0	0	1	1	
	F	0	0	0	1*	0	0	1	
Total		22	4	4	4	1	1	36	

[a] MRCP/IOC discrepancy (A/B, F/D and A/E)[a]

IOC	No of ducts	Operative findings 1	2	3		
	1	20	1[a]	0	21	0.001
	2	2[a]	11	1[a]	14	
	3	0	0	1	1	
Total		22	12	2	36	

[a] IOC/operative findings discrepancy (A/B, F/D, and A/E).

MRC, magnetic resonance cholangiography, IOC, intraoperative cholangiogram.

TABLE 2. Risk of biliary complications

Couinaud classification	n (%)	Biliary complication (%)	Bile leak (%)	Biliary stricture (%)	Biloma (%)	Cholangitis (%)	*P*	Odds ratio	95% CI
A	24 (66.6)	11 (45.8)	6 (25)	8 (33)	6 (25)	6 (25)	0.03	5.9	1.06–32.9
B	3 (8.3)	2 (66.7)	1 (33)	1 (33)	1 (33)	0			
C	4 (11.1)	3 (75)	3 (75)	0	1 (25)	0			
D	3 (8.3)	3 (100)	0	3 (100)	0	2 (66.7)			
E2	1 (2.7)	1 (100)	1 (100)	0	1 (100)	0			
F	1 (2.7)	1 (100)	1 (100)	0	1 (100)	1 (100)			

A B* = B, C, D, E, and F.

ation from the planned resection plane. When compared with actual biliary anatomy, MRC demonstrated biliary anatomy accurately in 33 of 36 (90%) patients. Specifically, MRC correctly delineated normal anatomy in 22 of 24 patients and aberrant anatomy in 11 of 12 patients.

Intraoperative cholangiography and biliary exploration revealed that 24 donors (66.6%) had conventional and 12 (33.3%) had aberrant biliary anatomy. Among the aberrant systems, three (8.3%) was type B, four (11.1%) were type C, three (8.3%) was type D, and one (2.7%) was type E and type F. Table 2 summarizes the donor anatomical variations encountered. The rates of biliary complication in recipients were 45.8%, 66.7%, and 75% for type A, type B, and type C, respectively, and 100% for types D, E, and F. The risk of developing biliary complications was 5.9 times higher if the biliary anatomy was any type other than A (P=0.03, CI 1.06–32.9) (Table 1). Logistic regression models controlling for donor age, type of anastomosis, ischemic times, arterial complications, and recipient age indicated an association between aberrant anatomy and the risk of recipient biliary complications (P=0.06).

Eleven of 24 patients with type A biliary anatomy had biliary complications, (bile leak in three, biliary stricture in five, and both leak and stricture in three), two patients with type B biliary anatomy had biliary complications (bile leak in one, biliary stricture in one), three patients with type C biliary anatomy had bile leak, three patients with type D biliary anatomy had biliary stricture, and one patient each with types E and F biliary anatomy had bile leak (Table 3). Among the donors, none of the donors developed biliary stricture. However, three donors did have biliary leak from the cut surface that required stenting in two and in one donor drainage decreased over 6 weeks and drain was removed. None of the donors returned to OR.

DISCUSSION

A greater incidence of biliary complications has been reported from the early series of LDLT, reaching up to 38%

TABLE 3. Postoperative biliary complications in recipients

No.	Donor age	Sex	MRC	Duct/Roux-en-y	Biliary complication	Leak	Stricture
2	47	2	A	Roux-en-y	Yes	No	Yes
4	44	2	A	Duct to duct	Yes	Yes	Yes
5	59	2	A	Duct to duct	Yes	Yes	Yes
6	44	2	A	Duct to duct	Yes	No	Yes
7	63	1	A	Roux-en-y	Yes	Yes	Yes
9	40	2	A	Duct to duct	Yes	No	Yes
12	46	2	A	Duct to duct	Yes	Yes	No
15	56	1	A	Roux-en-y	Yes	Yes	No
17	63	1	A	Roux-en-y	Yes	No	Yes
21	59	2	A	Roux-en-y	Yes	No	Yes
23	58	2	A	Roux-en-y	Yes	Yes	No
25	60	2	B	Duct to duct	Yes	Yes	No
26	53	1	B	Duct to duct	Yes	No	Yes
29	50	2	C	Duct to duct	Yes	Yes	No
30	44	2	C	Roux-en-y	Yes	Yes	No
31	55	2	C	Roux-en-y	Yes	Yes	No
32	49	2	D	Duct to duct	Yes	No	Yes
33	61	2	D	Roux-en-y	Yes	No	Yes
34	47	1	D	Duct to duct	Yes	No	Yes
35	62	1	E2	Roux-en-y	Yes	Yes	No
36	55	1	F	Duct to duct	Yes	Yes	No

MRC, magnetic resonance cholangiography.

(*12*, *13*). Biliary complications after live donor liver transplantation is not only caused by surgical technique, but also from anatomical variations in bile ducts. As shown by Couinaud (*14*) and confirmed by many liver surgeons, the anatomic variations of the right hepatic duct seem to be numberless. Our experience has shown that the risk of developing biliary complications was 5.9 times higher if the biliary anatomy was of any type other than A, further when allowed by the anatomy of the right hepatic duct in the donor, obtaining only one biliary orifice for the anastomosis in the graft seems to be an important factor in reducing the incidence of complications. Ten of the 14 recipients who had two or more anastomoses had a complication, Testa et al. (*4*) have reported similar results. A high rate of complications in our study is due to the following reasons. First, we were liberal in defining our biliary complications and included every complication no matter how minor they were. Second, majority of donors had variant anatomy that resulted in an overall higher rate of complications, and finally to avoid complications in donors, we sometimes had to deviate from the planned resection plane and ended up with more ducts. More than one hepatic duct leads to a technically more difficult anastomosis or a compromised blood flow to the hepatic ducts, making the anastomosis more prone to complication.

Accurate preoperative imaging is therefore essential to identify those donors with bile duct anomalies to facilitate intraoperative planning (*15–17*). Different groups have suggested various techniques to delineate biliary anatomy each with its inherent strength and weaknesses (*4*, *18–21*). Intraoperative cholangiography is considered the gold standard for imaging the biliary tree, but may not be helpful for obtaining a single bile duct orifice in some cases with anatomical variations because it does not allow a three-dimensional view. Endoscopic retrograde cholangiography is not routinely performed due to relatively high risk (1.4%–3.2%) of serious complications (*17*, *18*). Multidetector CT cholangiography has recently shown promise in delineating biliary tract in potential right lobe living donors (*16*, *19*). We found cholangionuclear magnetic resonance to be very accurate in delineating the intrahepatic biliary tree showing a strong correlation with IOC. Based on our findings, we have modified our practice and have included MRC to prescreen donors and to exclude donors with three or more ducts.

In this study, we show that MRC accurately delineated biliary anatomy and was highly predictive of the number of ducts. Based on preoperative anatomy, we were able to stratify the risk of biliary complication in the recipient. This may help to better educate patients in understanding the risk of complications associated with variant anatomy. Potential donors who are found to have a significant segmental left duct(s) that communicates with the right ductal system or those without a distinct bifurcation that may yield three or more small, intraparenchymal ducts can be excluded based on MRC findings (*22*).

In summary, our study demonstrates that MRC reliably identified variant biliary anatomy. The preoperative MRC demonstrated congruence with the IOC and intraoperative findings. Preoperative knowledge of aberrant ductal anatomy is helpful in assessing risk of biliary complications in recipients and to exclude donors with unsuitable ductal anatomy. Therefore, limiting the risk of unnecessary operation for donors. Careful and meticulous patient selection by preoperative imaging can potentially reduce the rate of biliary complications in recipients of LDLT.

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