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E. Chaib
P. J. Friend
N. V. Jamieson
R. Y. Calne

Biliary tract reconstruction: comparison of different techniques after 187 paediatric liver transplantations

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E. Chaib[1] (✉) · P. J. Friend
N. V. Jamieson · R. Y. Calne
Department of Surgery, Level 9,
Addenbrooke's Hospital, Hills Road,
Cambridge CB2 2QQ, UK

[1] *Present address:*
Hospital das Clinicas da Faculdade
de Medicina da Universidade
de Sao Paulo,
Departamento de Gastroenterologia –
9 andar, Clinica Cirurgica II,
Av. Dr. Eneas de Carvalho Aguiar 255,
05403 Sao Paulo, Brazil

Abstract Biliary complications after liver transplantation are common and cause significant morbidity and mortality. In order to evaluate the complications related to differents sort of biliary reconstruction, from January 1984 to July 1992 we retrospectively analysed 187 consecutive liver transplants in 136 paediatric patients at Addenbrooke's Hospital, Cambridge. There were 51 (27.2%) retransplantations. Biliary reconstruction consisted of: type 1 – common bile duct – Roux loop (CBD-RL); $n = 90$ (48.1%); type 2 – gallbladder conduit – Roux loop (GC-RL), $n = 51$ (27.2%); type 3 – gallbladder conduit – common bile duct (GC-CBD), $n = 20$ (10.6%); type 4 – common bile duct – common bile duct (CBD-CBD), $n = 18$ (9.6%); and type 5 – common bile duct – common bile duct + gallbladder drainage (CBD-CBD + GB), $n = 8$ (4.2%). There were, in all 26 biliary complications (14%). Of these 26 complications, biliary stricture was the most common (17/26; 65.3%) and 6 out of these 17 (35.2%) were associated with chronic rejection. Hepatic artery thrombosis was directly related to biliary leakage in 6 out of 26 (23.1%) biliary tract complications. This series demonstrated that type 1 and type 4 reconstructions were related to fewer biliary complications (9/90, 10% and 2/18; 11%, respectively) than the other techniques: 8/51 (16%) for GC-RL 5/20 (25%) for GC-CBD and 2/8 (25%) for CBD-CBD + GB ($P = 0.09$).

Key words Liver transplantation, biliary tract · Biliary tract reconstruction, pediatric liver transplantation · Pediatric liver transplantation, biliary tract

Introduction

Orthotopic liver transplantation has been performed in Cambridge/King's College Hospital since 1968, but the children's liver transplantation programme began in 1983, when suitable donor organs began to become available [17]. Although there have been great technological and immunological advances in liver transplantation, biliary complications remain an important cause of post-transplant morbidity and mortality: 16.6% and 9.6%, respectively [14]. A number of technical manoeuvres have been suggested to decrease the biliary complication rate, particularly those that would ensure optimum vascularisation of the biliary anastomosis.

To analyse the biliary tract complications with different types of biliary reconstruction, 187 consecutive paediatric liver transplantations were reviewed.

Patients and methods

Between January 1984 and July 1992, 187 consecutive liver transplants in 136 paediatric patients were analysed retrospectively at Addenbrooke's Hospital, Cambridge. Seventy patients (51%) were male and 66 (49%) female. The median age at the time of transplan-

Table 1 Indications for paediatric liver transplantation

Indication	Number
Biliary atresia	85
Alpha-1 antitrypsin deficiency	15
Tyrosinosis	6
Acute hepatic failure	6
Chronic active hepatitis	6
Metabolic disease	6
Oxalosis	3
Neonatal hepatitis	2
Inborn error metabolism	2
Alagille's syndrome	2
Sclerosing cholangitis	2
Cryptogenic cirrhosis	1
Total	136

tation was 5–7 years (range 3 months–16 years). The indications for liver transplantation are summarized in Table 1.

There were 134 whole liver transplants and 53 reduced-size liver transplants. Of the 53 reduced liver transplants, 42 involved the left lateral segment, 7 the right lobe, and 4 the left lobe. The techniques for reduced grafts have already been described [1, 2].

There were 51 (27.2%) retransplants and the causes were: chronic rejection ($n = 29$), liver infarction ($n = 13$), biliary stricture and cholangitis ($n = 5$) and primary non-function ($n = 4$).

The types of biliary reconstruction were:

Type 1 – Common bile duct – Roux loop (CBD-RL), $n = 90$ (48.1%)

An end-to-side choledochojejunostomy is performed with a single layer of interrupted 5 or 6.0 PDS suture. A 5 Fr silicone tube is brought out through Roux-en-Y distally and passed up into the biliary tree. The stent is then brought out through the abdominal wall. The gallbladder is removed.

Type 2 – Gallbladder conduit – Roux loop (GB-RL) $n = 51$ (27.2%)

A gallbladder conduit is constructed before transplanting the liver by anastomosing the donor common bile duct to Hartman's pouch as described elsewhere [4]. Then the fundus of the gallbladder is subsequently anastomosed to the recipient Roux-loop over a T tube that is brought out through the conduit. The donor gallbladder fundus is anastomosed to the Roux loop end-to-end using interrupted 4.0 prolene and continuous 5 or 6.0 PDS. The anastomosis is splinted with the small 2- or 4-mm T tube brought out through the gallbladder wall and then through a stab incision below the main wound.

Type 3 – Gallbladder conduit – common bile duct (GB-CBD), $n = 20$ (10.6%)

A gallbladder conduit is constructed before transplanting the liver by anastomosing the donor common bile duct to Hartman's pouch. Then the fundus of the gallbladder is subsequently anastomosed to the recipient common bile duct as described by Calne [4].

Type 4 – Common bile duct – common bile duct (CBD-CBD) $n = 18$ (9.6%)

An end-to-end choledochocholedochostomy is performed between the recipient and donor common bile duct with a 5 or 6.0 PDS suture utilizing a single interrupted layer. The anastomosis is splinted with the upper limb of a no. 8 or 10 T tube, which is inserted into the supraduodenal portion of the recipient's own common bile duct. The T tube is then brought out through the abdominal wall. The gallbladder is removed.

Type 5 – Common bile duct – common bile duct + gallbladder drainage (CBD-CBD + GB), $n = 8$ (4.2%)

An end-to-end choledochocholedochostomy is performed between the recipient and donor common bile duct as with type 4 reconstruction but without any stenting of the bile duct. Then a no. 12 or 14 Foley catheter is placed in the donor gallbladder and brought out through the abdominal wall.

Biliary strictures were treated either by surgical intervention or by percutaneous transhepatic dilatation, as described elsewhere [22]. Median follow-up was 15 months (range 2 months–3 years).

All patients were given a combination of cyclosporin, steroid, and azathioprine immunosuppression. Antithymocyte immunoglobulin was used prophylactically in later patients. Abdominal ultrasound was performed on all patients routinely on the 1st postoperative day to confirm vascular patency. Cholangiograms were performed after the 10th postoperative day prior to clamping the bile tube. When indicated, subsequent cholangiography was obtained by endoscopic retrograde cholangiopancreatography or percutaneous transhepatic cholangiography.

The chi-square test for overall comparison and relative risk (odds ratio) was used for statistical analysis.

Results

There were 26 biliary complications in 187 liver transplants (14%), combinations with biliary stricture ($n = 17.9\%$) or with biliary leakage ($n = 9.5\%$).

The CBD-RL and CBD-CBD anastomoses yielded fewer biliary complications – 9/90 (10%) and 2/18 (11%), respectively – than the other sorts of biliary reconstruction ($P = 0.09$). However, the occurrence of strictures and leakages was independent of the type of other biliary tract anastomosis: 8/51 (16%) for GC-RL, 5/20 (25%) for GC-CBD and 2/8 (25%) for CBD-CBD + GB.

The occurrence of biliary stricture was associated with the development of chronic rejection in six cases. Hepatic artery thrombosis was related to biliary leakage in six cases. The biliary complications related to each sort of biliary reconstruction are summarized in Table 2.

Biliary strictures were managed by percutaneous transhepatic dilatation in ten cases and by surgery in seven. All of the biliary leaks were treated by revising the biliary reconstruction. Hepatic artery thrombosis were managed by surgical revision of the anastomosis or by retransplantation. Overall, 16 of the 26 patients with biliary complications (61.5%) required operative intervention.

Table 2 Biliary complications after 187 paediatric liver transplantations. BS, Biliary stricture; C, cholangitis; CR, chronic rejection; BL, biliary leakage; HAT, hepatic artery thrombosis; P, peritonitis. *P = 0.09 for types 1 and 4 versus types 2, 3 and 5

Biliary reconstruction		Type 1 (n = 90)	Type 2 (n = 51)	Type 3 (n = 20)	Type 4 (n = 18)	Type 5 (n = 8)
Biliary complications						
BS&C	n = 11	4 (4.5%)	3 (6%)	2 (10%)	1 (5.55%)	1 (12.50%)
BS&C&CR	n = 6	3 (3.5%)	2 (4%)	1 (5%)		
BL&HAT	n = 6	2 (2%)	2 (4%)	1 (5%)		1 (12.50%)
BL&P	n = 3		1 (2%)	1 (5%)	1 (5.55%)	
Total	n = 26	9 (10%)*	8 (16%)	5 (25%)	2 (11%)*	2 (25%)

The chi-square test was used to estimate the significance when comparing the distinct types of biliary tract reconstruction techniques. Comparing types 1 and 4 with the other three types of reconstruction grouped together, the odds ratio (OR) of developing any complication was estimated as being 2.07 (0.83 < OR 95% < 5.19) with $X^2 = 2.95$ ($P = 0.09$).

Discussion

Biliary complications remain a significant source of postoperative morbidity and mortality. Strictures and leakages account for most of these complications, which are usually recognised within weeks of transplantation [14]. The morbidity ad mortality rates after orthotopic liver transplantation in early studies were 34%–50% and 25%–30%, respectively, as a result of biliary complications [6, 18].

Biliary tract complications may be related to ischemia, technical error or immunological factors. Refinement and standardisation of biliary reconstructive techniques have lowered the incidence of biliary tract complications [10, 14, 19]. Yet, it remains considerable, ranging from 12% to 37% [9, 10, 14, 16, 19, 21, 23, 24]. In our series, the biliary tract complication incidence was 14% (26/187).

Direct anastomosis of the common bile duct to a Roux loop or CBD-CBD reconstruction were associated with significantly fewer complications – 9/90 (10%) and 2/8 (11%), respectively – than the other three types of anastomosis: 8/51 (16%) for GC-RL; 5/20 (25%) for GC-CBD and 2/8 (25%) for CBD-CBD + GB; $P = 0.09$.

Although the results of this statistical analysis are not significant at the level of 5%, the relative risk is equal to 2.95, meaning that a patient's chance of developing some biliary tract complication when type 1 or type 4 reconstruction was not applied was 2.95 times greater than when either of these techniques was, in fact, applied.

These results show improvement when compared with findings from our early studies where we had a 31% complication rate for CBD-CBD, 28% for GC-RL and 48% for GC-CBD [17]. These findings are in line with those of other groups [3, 13].

Hepatic artery thrombosis is a major factor in biliary tract complications as the perfusion of the donor common bile duct is largely dependent upon hepatic artery blood flow. A number of factors are associated with the development of hepatic artery thrombosis, including vessel size and postoperative synthesis of anticoagulant factor [15]. The incidence of hepatic artery thrombosis in this series was 6/187 (3.2%), which compares favourably with other reports of 4% for adult patients, 12% for paediatric liver patients [5, 8, 20] and as much as 30% for children under 1 year of age [7].

Most liver transplant centres currently use an end-to-end choledochocholedochostomy or Roux-en-Y choledochojejunostomy, depending on the patient's age and pathology [11, 12, 14]. Improvements in techniques and management have resulted in a lower incidence of biliary complications. In addition, early recognition and intervention have reduced the associated morbidity and mortality [14, 19, 24].

In conclusion, this series demonstrates that direct anastomosis of the donor common bile duct to a Roux loop or CBD-CBD reconstruction are the most effective ways to reconstruct the biliary tract after paediatric liver transplantation.

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References

1. Bismuth H, Houssin D (1984) Reduced-sized orthotopic liver graft in hepatic transplantation in children. Surgery 95: 367–370
2. Broelsch CE, Emond JC, Thistlethwaite JR, Rouch DA, Whitington PF, Lichtor JL (1988) Liver transplantation with reduced size donor organs. Transplantation 45: 519–523
3. Busuttil RW, Colonna JO II, Hiatt JR, Brems JJ, Khoury GE, Goldstein LI, Quinones-Baldrich WJ (1987) The first 100 liver transplants at UCLA. Ann Surg 206: 387–389

4. Calne RY (1976) A new technique for biliary drainage in orthotopic liver transplantation utilizing the gall bladder as a pedicule graft conduit between the donor and recipient common bile ducts. Ann Surg 184: 605–609
5. Calne RY (1987) Blockage of hepatic artery. In: Calne RY (ed) Liver transplantation: the Cambridge-King's College Hospital experience, 2nd edn. Grune & Stratton, New York, p 245
6. Calne RY, McMaster P, Portmann B, Wall WJ, Williams R (1977) Observations on preservation, bile drainage and rejection in 64 human orthotopic liver allografts. Ann Surg 196: 282–289
7. Esquivel CO, Koneru B, Karrer F, Todo S, Iwatsuki S, Gordon RD, Makowka L, Marsh WJ, Starzl TE (1987) Liver transplantation before 1 year of age. J Pediatr 110: 545
8. Gordon RD, Makowka L, Brosther OL, et al. (1987) Complications of liver transplantation. In: Toledo-Pereira LH (ed) Complications of organ transplantation. Dekker, New York, p 329
9. Hiatt JR, Quinones-Baldrich WJ, Ramming KP, Brems J, Busuttil RW (1987) Operations upon the biliary tract during transplantation of the liver. Surg Gynecol Obstet 165: 89–93
10. Hollins RR, Wood RP, Shaw BW Jr (1988) Biliary tract reconstruction in orthotopic liver transplantation. Transplant Proc 20 [Suppl 1]: 543–545
11. Iwatsuki S, Shaw BW Jr, Starzl TE (1983) Biliary tract complications in liver transplantation under cyclosporin-steroid therapy. Transplant Proc 15: 1288–1291
12. Krom RAF, Kingma LM, Haagsma EB, Wesenhagen H, Slooff MJH, Gips CH (1984) Choledochocholedochostomy, a relatively safe procedure in orthotopic liver transplantation. Surgery 97: 552–556
13. Krom RAF, Wiesner RH, Rettke SR, Ludwig J, Southorn PA, Hermans PE, Taswell HF (1989) The first 100 liver transplantations at The Mayo Clinic. Mayo Clin Proc 64: 84–94
14. Lerut J, Gordon RD, Iwatsuki S, Esquivel CO, Todo S, Tzakis A, Starzl TE (1987) Biliary tract complications in human orthotopic liver transplantation. Transplantation 43: 47–51
15. Mazzaferro V, Esquivel CO, Makowka L, Belle S, Kahn D, Koneru B, Scantlebury VP, Stieber AC, Todo S, Tzakis AG, Starzl TE (1989) Hepatic artery thrombosis after pediatric liver transplantation – a medical or surgical event? Transplantation 47: 971–977
16. Pinson CW, Lopez RR, Benner KG, Keeffe EB, Parayko MK, Sasaki AW, Bowers DK, Wheeler LJ, Lee RG, Johnson RS, Campbell JA, Goodnight SH, Davis RR, Deveney CW (1991) Initial two-year results of the Oregon liver transplantation program. Am J Surg 161: 606–611
17. Salt A, Noble-Jamieson G, Barnes ND, Mowat AP, Rolles K, Jamieson N, Johnston P, Friend P, Calne RY (1992) Liver transplantation in 100 children: Cambridge and King's College Hospital Series. BMJ 304: 416–421
18. Starzl TE, Putnam CW, Hansbrough JF, Porter KA, Reid HAS (1977) Biliary complications after liver transplantation: with special reference to the biliary cast syndrome and the techniques of secondary duct repair. Surgery 81: 212–221
19. Stratta RJ, Wood RP, Langnas AN, Hollins RR, Bruder KJ, Donovan JP, Burnett DA, Lieberman RP, Lund GB, Pillen TJ, Markin RS, Shaw BW Jr (1989) Diagnosis and treatment of biliary tract complications after orthotopic liver transplantation. Surgery 106: 675–684
20. Tzakis AG, Gordon RD, Shaw BW, Iwatsuki S, Starzl TE (1985) Clinical presentation of hepatic artery thrombosis after liver transplantation in the cyclosporine era. Transplantation 40: 667
21. Vicente E, Perkins JD, Sterioff S, Kiely M, Rakela J, Krom RAF (1987) Biliary tract complications following orthotopic liver transplantation. Clin Transplant 1: 138–142
22. Ward EM, Kiely MJ, Mans TP, Wiesner R, Krom RAF (1990) Hilar biliary strictures after liver transplantation: cholangiography and percutaneous treatment. Radiology 177: 259–263
23. Zajko AB, Campbell WL, Bron KM, Lecky JW, Iwatsuki S, Shaw BW Jr, Starzl TE (1985) Cholangiography and interventional biliary radiology in adult liver transplantation. Am J Roentgenol 144: 127–133
24. Zajko AB, Campbell WL, Bron KM, Schade RR, Koneru B, Van Tiel DH (1988) Diagnostic and interventional radiology in liver transplantation. Gastroenterol Clin North Am 17: 105–143