787

Surgical complications
in human orthotopic liver transplantation

J. Lerut, R. D. Gordon, S. Iwatsuki and T. E. Starzl

From the Departments of Surgery, University Health Center of Pittsburgh, University of Pittsburgh, and the Veterans Administration Medical Center, Pittsburgh, Pennsylvania, USA

Key Words. Liver diseases ; transplantation ; surgery, digestive system ; postoperative complications ; prognosis

Abstract. Between March 1, 1980 and December 31, 1984, 393 orthotopic liver transplantations (OLT) were performed in 313 consecutive recipients.

Technical complications were responsable for a substantial morbidity (41/393 allograft loss — 10,4%) and mortality (26/313 patient loss — 8,3%).

Failure of the biliary tract reconstruction, mainly expressed as leakage and obstruction, is the most frequent complication of OLT (52/393 grafts — 13,2%). Biliary tract complication (BTC) was directly responsible for 5 deaths (9,6%).

Reliance upon standardized methods of direct duct-to duct repair with T-tube (CC-T) and Roux-Y choledocho-jejunostomy (RYCH-J), appropriate postoperative investigation and treatment will reduce morbidity and mortality of BTC. A complicated CC-T will be conversed to a RYCH-J ; a complicated RYCH-J needs surgical correction.

Hepatic artery thrombosis (HAT) has become the "Achilles heel" of OLT. HAT is expressed by three different patterns : fulminant hepatic necrosis, delayed bile leakage and relapsing bacteremia. Diagnosed in 27 grafts (6,8%), HAT was responsible for 16 deaths (16/25 pat : 64%). The only chance to rescue patients presenting HAT is an early diagnosis and prompt retransplantation before occurrence of septic complications.

Aneurysm of the hepatic arterial supply (4/393 grafts — 1%) also needs aggressive surgery because of the high rate of fatal rupture (3/4 pat — 75%).

The incidence of *thrombosis* of the reconstructed *portal vein* (PVT) was only 2,2% (7 pat.), three inferior *vena caval thromboses* (0,9%) (CVT) were diagnosed after OLT. Four of the 7 patients whose portal veins clotted are alive. Three have their original graft. One patient, presenting both PVT and CVT, was rescued by prompt retransplantation. PVT was responsible for 3 patient (3/7 pat — 42,8%) and 4 graft losses (4/7 pat — 57%). The rate of graft (3/3) and patient loss (2/3) was even higher after CVT.

Introduction

Orthotopic liver transplantation (OLT) has become an accepted therapy for endstage liver disease. Standardization of techniques, clinical use of veno-venous bypass and introduction of new immunosuppressive drugs are the main factors in the dramatic improvement of the results of OLT during the last 5 years (6, 27, 28).

About 10% of the liver allografts are still lost from technical surgical failures (4). This report analyzes incidence, nature, treatment and outcome of primary surgical failures of arterial, venous and biliary reconstructions in a series of 393 OLTs performed on 313 consecutive patients during the cyclosporine-steroid era.

Materials and methods

Case material

Between March 1, 1980 and December 31, 1984, 313 patients, including 177 adults and 136 children, received a primary OLT in the Colorado-Pittsburgh series under the cyclosporine-steroid regimen. 68 patients underwent a second transplant during the same time period and 12 patients required a third transplant.

All patients were followed for at least one year after OLT or until death. The intra- and perioperative mortality is 3,8% (12/313 pat.). 280 patients (89,4%) lived for more than 3 months postoperatively.

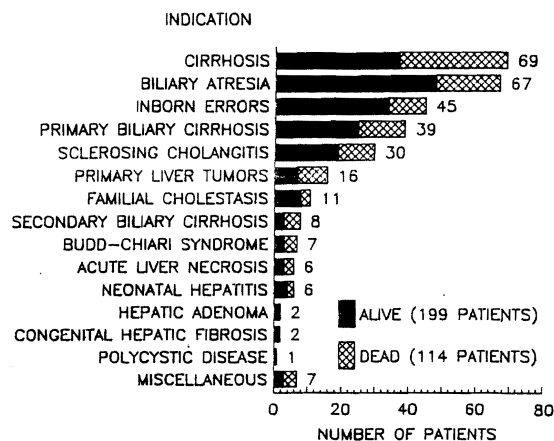The indications for primary grafts are summarized in Figure 1.

INDICATION

Fig. 1

Indications in 393 OLT performed on 313 patients during the cyclosporine era.

Immunosuppression

All patients were treated with combination cyclosporine-prednisone therapy (6, 24, 27, 28). Since september 1984, monoclonal ALG (OKT3 — Orthoclone®) was used for the treatment of rejection (3).

Surgical techniques

The techniques of donor and recipient operation have been thoroughly described (25, 27, 28). Some details of these operations, pertinent to the described technical complications, are stressed.

During the donor hepatectomy, the individual structures of the liver hilum are skeletonized. The common bile duct is divided as distally as possible and the biliary system is flushed with saline through an incision in the fundus of the gallbladder. This prevents damage to the bile duct epithelium from residual bile (11, 25).

Special attention should be given to the arterial hepatic supply as anomalies occur in up to 25% (5, 13, 25). A left hepatic artery will be preserved in continuity with the main left gastric artery and the coeliac trunk (CT). In case of a right hepatic artery (HA), both CT and SMA are dissected out in order to allow a fold-over technique during implantation (5).

Arterial and venous grafts are always obtained at the end of the donor operation in order to overcome the impossibility to anastomose donor hepatic vascular supply to an inconvenient or diseased recipient artery or vein.

Since February 1983, OLT is performed using a non-heparin, external pump-driven veno-venous bypass. The bypass, used systematically in adults and in selected children, greatly facilitates OLT by decompressing the occluded venous pouls (28).

Before sewing in a new liver, adequate arterial and venous cuffs should be prepared. Anastomotic arterial and venous strictures are avoided, using the "growth factor technique" (26).

Nine (2,9%) of the 313 recipients had pre-existing abnormalities of the inferior caval vein (ICV). Five were children with biliary atresia ; 4 adult patients presented with a caval vein thrombosis (CVT) (2 pat.) and an aneurysmal dilatation (2 pat.). The technical adjustments made to these anomalies are listed in table I (9, 12). Absence of the superior vena cava with drainage of both innominate veins into the IVC was responsible for irreversible brain damage during cross clamping of the IVC.

Table I

Pre-existing inferior vena cava (IVC) abnormalities in 9 (2,9%) of 313 recipients (1980-1984)

Description of abnormality	Liver disease	# cases	Technical adjustment
Absent retrohepatic IVC	Biliary atresia	2	Suprahepatic graft IVC anastomosis to recipient hepatic vein cloaca or right atrium ; ligation infrahepatic IVC of graft.
Extrahepatic IVC ; main hepatic veins into cloaca	Biliary atresia	2	Upper graft IVC anastomosis to hepatic vein cloaca ; ligation infrahepatic IVC of graft.
Absent superior vena cava ; innominate vein drainage to IVC	Biliary atresia	1	Anomaly not recognized : brain death resulted from innominate hypertension during IVC occlusion of anhepatic period.
Thrombosis IVC	Budd-Chiari syndrome	2	Thrombectomy IVC, in one case including renal, iliac and femoral veins.
Aneurysm IVC	After portal systemic shunt	2	Conventional IVC anastomoses with adjustment for for size discrepancy : shunt taken down.

Table II

Portal vein abnormalities in 51 (16,3%) of 313 recipients (1980-1984)

	Number	Principal association(s)	Technical adjustment(s)
Thrombosis	22	9 none ; 9 previous shunt or other hilar operation ; 2 Budd-Chiari ; 2 tumor	Thrombectomy ; dissection to SV-SMV confluence ; iliac vein or pulmonary artery graft to add length.
Hypoplasia	20	14 biliary atresia ; 5 cirrhosis ; one sclerosing cholangitis	Dissection to SV-SMV confluence ; vein graft sometimes.
Phlebosclerosis	8	4 previous shunt or other hilar operation ; 4 unknown	Dissection to SV-SMV confluence : vein graft sometimes.
Absent portal vein	1	Biliary atresia ; previous hilar dissection	Portacaval transposition.

SV = Splenic Vein ; SMV = Superior Mesenteric Vein.

Table III

Relation between previous operations on the splanchnic circulation
and portal vein complications

Type operation	Number	Abnormal portal vein at OLT	Technical solution	Outcome
Portacaval shunt	7	3 thrombosed	Thrombectomy	1 completely successful ; 2 thrombosed but survival
		2 sclerotic	No solution	2 died of bleeding
Central spleno-renal shunt	2	2 small	Shunts ligated	2 survived
Mesocaval shunt	3	2 small	2 shunts ligated ; 1 had thrombosed	2 survived
Splenectomy	9	3 thrombosed	Thrombectomy and dissection to confluence of SV-SMV	1 died late thrombosis
		1 sclerotic	Dissection to confluence	1 survived
		1 absent	Portacaval transposition	Died, no hepatic function
Total	21	14		

Anomalies of the portal vein were present in 51 (16,3%) of the 313 recipients. The most frequent conditions were portal vein thrombosis and hypoplasia (table II).

Fourteen of the 20 recipients presenting a PV hypoplasia had the diagnosis of biliary atresia.

The combined incidence of PV or/and CV anomalies was 17 (23,3%) of 72 children with biliary atresia.

The technical adjustments required by portal vein anomalies included thrombectomy or retrograde dissection of the abnormal vein to the confluence of the splenic and superior mesenteric veins (31 patients) (table II).

In 9 patients portal inflow could only be realised after interposition of a free graft of donor iliac vein, pulmonary artery or inferior vena cava (20).

The adverse influence of portal hypertension surgery on OLT is clearly demonstrated in table III. Technical adjustment at time of OLT was unsuccessfull in 6 of the 14 patients presenting with a portal vein abnormality (9).

A free iliac graft (39 ×), a fold-over technique (26 ×), an abdominal (14 ×) and a thoracic (8 ×) aortic graft had to be used in 90 OLTs (23,4%) in order to restore arterial graft supply (13).

The free arterial grafts are sewn into the recipient infrarenal aorta and are tunneled under the pancreas to reach the donor hepatic hilum.

When retransplantation (re-OLT) becomes necessary a cuff of suprahepatic caval vein greatly simplifies the procedure (21). A cuff of hepatic artery and of infrahepatic caval and portel veins was only occasionally retained.

Biliary reconstruction is deferred until completion of all vascular anastomoses and of hemostasis.

If both donor and recipient ducts are suitable, a primary choledocho-choledochostomy over a T-tube (CC-T) is performed.

If preexisting biliary tract disease or inadequacies of duct size do not permit a direct duct to duct anastomosis, a 45 cm Roux-en-Y limb of proximal jejunum is used to perform and end to side choledocho-jejunostomy over an internal stent (RYCJ-S) (11).

The Waddell-Calne procedure (2, 30), in which the gallbladder is used as a conduit between donor and recipient biliary tract, primary duct reconstruction over an internal stent, cholecysto-enterostomy, tube-cholecystostomy or -choledochostomy and simple external drainage have been used only in exceptional circumstances.

Results

Survival for the 313 patients and 393 grafts is presented in Figure 2. There are 199 (63,6%) surviving patients. Patient survival is 63% at one year and 59,9% at five years.

Technical complications, occurred in 92 of the 393 (24,4%) grafts and were responsible for the loss of 41

grafts (10,4%) and 26 patients (8,3%). Twenty-six re-OLTs were performed for technical failures of a previous graft, 15 of which were successful (Table IV).
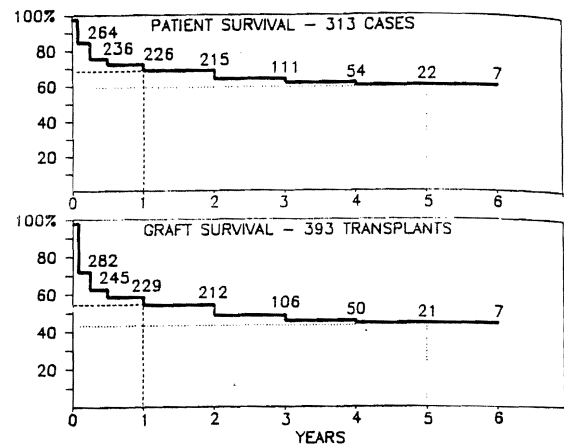

Fig. 2

Actuarial allograft and patient survival of 393 OLT performed on 313 patients.

Table IV

Technical complications in 393 orthotopic liver transplants

Complication	Grafts (393)		Patients (313)		Retransplantations		Deaths		
					successful	failed	unrelated	related	
Biliary tract	52*	(13.2%)	52*	(16.6%)	3	1	2	5	(9.6%)
Hepatic artery									
thrombosis	27°	(6.8%)	25°●・	(7.9%)	11	8	–	16●	(64.0%)
aneurysm	4	(1.9%)	4●	(1.2%)				3●	(75.0%)
Portal vein									
thrombosis	6	(1.5%)	6	(1.9%)	–	1	1	2	(40.0%)
stenosis	2*○	(0.5%)	2*○	(0.6%)	–	–	–	–	
Portal vein									
and inferior vena									
cava thrombosis	1	(0.3%)	1	(0.3%)	1	–	–	–	
Inferior vena									
thrombosis	2	(0.5%)	2	(0.6%)	–	1	1	1	(50.0%)
Total	92	(24.4%)	89	(28.4%)	15	11	6	26	(8.3%)
						graft loss 41/393 – 10,4%			

*/⁻/ᵏ same patients

Biliary tract complications (BTC) occurred in 52 of the 393 grafts (13.2%) and thus accounted for 56.5% of the 92 technical failures (Table V). There were 17 failures in pediatric grafts (10%) and 35 failures in adult grafts (16,2%). The incidence of biliary tract

complications had declined significantly from 24,4% during 1980-82 to 8% in 1984.

Choledocho-choledochostomy with T-tube stent (CC-T) was used in 159 reconstructions, including 24 children

Table V

Primary biliary complications according to technique of reconstruction

Type	CC-T	CC-S	RYCJ-S	Waddell-Calne	Cholecysto-enterostomy	External drainage
Number	159	32	175	6	7	5
Successes	139 (87.4%)	18 (56.2%)	166 (94.8%)	5 (83.4%)	1 (14.3%)	-
Failures	20 (12.6%)	14 (43.8%)	9 (5.2%)	1 (16.6%)	6 (85.7%)	2 (40.0%)
Biliary leak	15	7	3	1	1	-
Obstruction	5	5	4	-	5	1
Hemobilia	-	2	-	-	-	1
Torsion of Roux limb	-	-	1	-	-	-
Biliary cast syndrome	-	-	1	-	-	-
Intrahepatic strictures	-	-	1	-	-	-

and 135 adults. Complications occurred in 20 cases (12,6%), including 4 pediatric cases (16,6%) and 16 adult cases (11,8%).

Biliary leakage was the most common complication. Eleven leaks occurred at the T-tube exit site with no or minimal symptoms. Simple drainage or closure of the opening in the bile duct was sufficient treatment in most cases.

Leakage at the biliary anastomosis, which occurred in 4 patients, was a serious complication. Two patients died of sepsis and another required retransplantation after failure of an attempt at direct repair.

Biliary tract obstruction occurred in 5 cases, four of which presented within 90 days of transplantation. In 3 patients the obstruction was caused by the T-tube itself and in 2 of these it was resolved by removal of the T-tube. One patient developed obstruction at the duct anastomosis which was successfully treated by percutaneous transhepatic balloon dilatation (PTD). Ten months later, the patient required endoscopic removal of common bile duct stones. The fifth patient developed a stricture of the proximal common hepatic duct which was treated by PTD but recurred within 2 years necessitating conversion to a choledocho-jejunostomy (Fig. 3 A-D).

Choledocho-choledochostomy with internal stent (CC-S) was done in 17 children and 15 adults. Complications occurred in 14 cases (43,8%), including 6 pediatric (35,3%) and 8 adult patients (53,3%). There were 7 biliary leaks, 5 obstructions, and 2 cases of hemobilia. Two patients died as direct consequence of these complications, one of sepsis, another of liver graft failure.
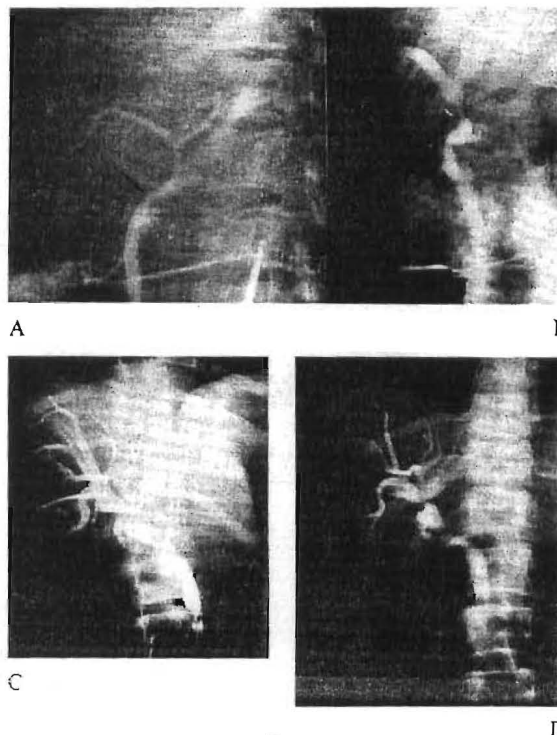

Fig. 3
Biliary tract complications after OLT.
A. Operative cholangiography : normal duct-to-duct reconstruction with T-tube. The anastomosis (✓✓) is situated in between donor (*) and recipient (*) cystic ducts (CC-T).
B. Post-operative cholangiography shows stricture at the confluence of the donor hepatic ducts (in the presence of normal arterial allograft supply).
C. Temporary relief of stricture after percutaneous balloon dilatation.
D. Recurrence of stricture 1 1/2 years later treated definitively by conversion of CC-T into Roux-en-Y choledochojejunostomy.

All seven biliary fistulas occurred at the biliary anastomosis soon after operation. Conversion to RYCJ-S was successful in 2 of 4 patients. Conversion to CC-T was attempted in 3 cases but was only successful in one. One patient developed a second leak and was successfully converted to RYCJ-S.

A fistula between the hepatic artery and common bile duct caused a lethal rupture of a mycotic hepatic artery aneurysm in one case 2 months after OLT. Hemobilia, 2 1/2 year after transplantation, caused by irritation of the ampulla of Vater by a retained stent, was resolved by endoscopical removal of the stent.

Four of the 5 obstructions after CC-S occurred more than 3 months after transplantation. One was managed by removal of the stent at 8 months. Multiple stones were later found in the bile duct when the patient was retransplanted for chronic graft rejection. One patient was successfully treated by PTD. Three patients were successfully converted to RYCJ-S, including one patient who also had successful portal vein thrombectomy and resection of a portal vein stenosis.

Choledocho-jejunostomy with internal stent using a Roux-en-Y limb (RYCJ-S) was used in 175 reconstructions, including 126 children and 49 adults. Complications occurred in only 9 cases (5,1%), including 3 pediatric (2,3%) and 6 adult petients (12,2%).

There were 2 anastomotic leaks and one leak caused by a tear in the donor duct near the cystic duct which had been used to insert the stent. All were successfully repaired by revision of the choledocho-jejunostomy.

Three patients required laparotomy for removal of a retained stent causing functional biliary obstruction. In a fourth patient, with clinical signs of obstruction, intra-operative cholangiography failed to find a site of stenosis. The anastomosis was stented with a T-tube.

One patient developed torsion of the Roux-en-Y jejunal limb 3 months after transplantation. A new jejunal limb was constructed.

A 9-year old boy transplanted for Allagille's syndrome developed dilatation of the intrahepatic bile ducts with numerous casts filling the ducts. Despite absence of obvious anastomotic obstruction conservative management was finally followed by successfull re-OLT.

Other reconstructions

The Waddell-Calne gallbladder conduit was used in only 4 pediatric and 2 adult patients. Since 2 patients died of early graft failure and 2 patients had an early re-OLT using another method of reconstruction, our experience with this method is too limited for meaningful evaluation.

Cholecysto-duodenostomy (1 case) or cholecysto-enterostomy (6 cases) were used in 3 pediatric and 4 adult patients.

Complications occurred in 6 cases. One patient died as a result of an unrecognized bile leak from a faulty ligature on the distal common bile duct. One pediatric patient developed a large fungal liver abscess 2 weeks after surgery and was successfully retransplanted using RYCJ-S. In four patients, early obstruction of the cystic duct required conversion to RYCJ-S. One of these patients died within 3 weeks of hepatic failure and sepsis and another required retransplantation for an injury to the portal vein which occurred at reoperation.

External biliary drainage was performed in 2 pediatric and 3 adult patients who were unstable and required rapid completion of surgery. Two patients survived and required early converson to RYCJ-S because of bleeding in the gallbladder or obstruction.

Hepatic artery thrombosis after OLT occurred in 25 patients (8%) and 27 grafts (6,8%) (Fig. 4). Three types of clinical presentation have been observed after HAT (29) (Table VI).

Three adults and three children, experienced a *massive hepatic necrosis* leading to a rapid liver failure and sepsis. Plain abdominal films showed gasbubbles in the right upper quadrant in two patients.

The average time of presentation of these symptoms was 8 days ± 7 after OLT. Sudden and sharp rises in the serum transaminase levels (more than 100-fold over normal) were always present. All 6 patients died despite retransplantation in three (100% mortality).

Six children and 2 adults manifested a *delayed bile leak* 15,4 days ± 5,8 after OLT.
A 3-years old child presented 3 times a HAT, manifested twice as a bile leak, once as a bacteremia.
All 8 patients had persistent fever and deteriorated liver function test (LFT). Gramnegative germs were present in the blood cultures of 6 patients.
CT-scan showed a biloma in 5 patients (fig. 4).
Both non-retransplanted patients and, two of the 6 retransplanted patients died. A third patient died of a ruptured mycotic arterial aneurysm 5 months after re-OLT. The mortality in this subgroup was 62,5% (5/8 pat.).

Eight pediatric and 3 adult patients presented with a *relapsing bacteremia* usually associated with normal or sub-normal LFT, about 2 months after OLT (61.5 days ± 90.5). The repeated episodes of bacteremia

Table VI

Hepatic artery thrombosis in OLT — clinical expression

	N grafts	Outcome	
		retranspl.	death
Fulminant — Hepatic gangrene	6	3	6
Relapsing bacteremia	12* ᵓ	9	5
Biliary leak	9**	7	5 ᶻ ●
stricture	1 ᵓ		
		19	16
		19/27 grafts	16/25 pat.
		70%	64%

ᵓ/* : same patients

ᵃ : death due to primary non-function of second graft

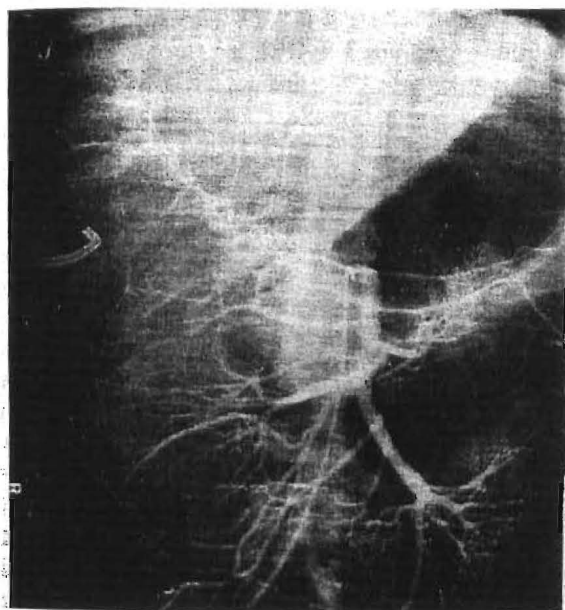● : death due to late rupture of mycotic aneurysm

A

B

Fig. 4

Hepatic artery thrombosis after OLT (HAT).
A. Selective superior mesenteric arteriography showing extensive collateral circulation in the right upper quadrant after HAT.
B. Hypodense zone in the allograft on liver CT-scan corresponding to the biloma demonstrated by percutaneous transhepatic cholangiogram.

usually responded to appropriate intravenous antibiotics. Five of nine re-OLT were successful. Three patients in this sub-group have not been retransplanted ; two survived with their dearterialized graft, a third developed a late stricture of the choledocho-jejunostomy, successfully treated by PTD. The overall mortality of this group is 45% (5/11 pat.).

Table VII

Hepatic artery thrombosis in 393 OLT-relation
to age group

Age	0-2	3-6	7-11	12-18	adult	total
	4	11	3	1	8	27
		19/177			8/216	27/393
		10.7%			3.7%	9.4%

A precise analysis revealed a markedly higher incidence of dearterialized liver allografts in pediatric patients and in those patients requiring complex vascular reconstructions, although these procedures were equally spread throughout the different age groups (Tables VII and VIII) (13, 29).

A technical failure could be demonstrated as the cause of HAT in 11 of the 25 patients (44%).

Despite of the high retransplantation rate (19/27 grafts — 70%), HAT proved to be a highly letal condition (16/25 pat — 64%). Even with retransplantation, the mortality of HAT has been 55,5% (10/18 pat.).

Aneurysm of the arterial allograft supply occurred once after hepatic artery to hepatic artery anastomosis, three times after use of donor vessel graft (4/313 graft — 1%). Three patients died of an aneurysmal rupture

Table VIII

Hepatic artery thrombosis in 393 OLT-relation
to type of vascularisation

fold-over graft	fold-over-HA	graft-HA	HA-HA	total
0	5	10	12	27
	15/90		12/295	27/393
	16.6%		4%	9.4%

(75%) ; the fourth patient had a successful aneurysmal repair.

Seven (2,2%) of the 313 patients developed a *portal vein thrombosis* (PVT) after OLT. The incidence relative to the 393 grafts was 1.8%. Four of the 7 recipients had satisfactory early convalescence. The diagnosis was made when the patients developed evidence of portal hypertension including variceal hemorrhage, persistence of esophageal varices, splenomegaly and hypersplenism.

Portal inflow was restored in only one of these 4 patients 8 months after OLT by realising thrombectomy and reperformance of the portal vein anastomosis. Sclerotherapy and splenorenal shunt was necessary in one patient to control esophageal varices. In both patients the hilar portal vein of the graft has been revascularized by venous collaterals (Fig. 5).
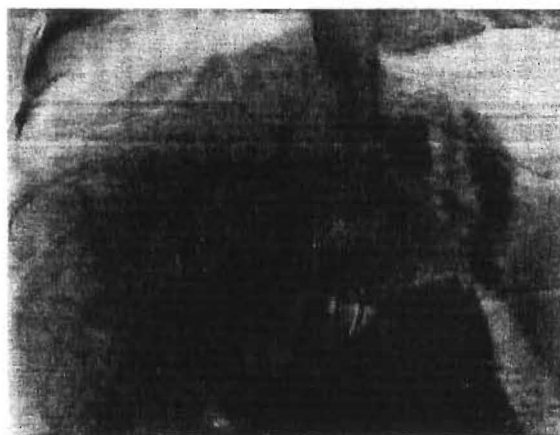

Fig. 5
Portal vein thrombosis after OLT (PVT).
Venous phase of selective superior mesenteric arteriography showing portal venous revascularization of the liver by venous collaterals one year after OLT.

The 4th patient had a pre-existing thrombosis of portal, splenic and mesenteric veins. At the time of OLT thrombectomy was possible ; when the patient

died 14 months later, the portal and superior mesenteric veins had clotted.

The other 3 patients were desperately ill after OLT. Two developed acute liver failure and were retransplanted early. One child, presenting both PVT and caval vein thrombosis (CVT), survived. The third patient, undergoing a re-OLT for chronic graft rejection, developed a PVT due to major size disparity between donor and recipient. The patient finally died of liver failure.

Four of the 7 patients whose portal vein clotted are still alive 3 to 5 years later ; 3 have their original grafts and one was rescued with re-OLT. PVT was favorised by discongruency between donor and recipient PV (1), PV hypoplasia (1) and previous portal hypertension surgery (3). There were 3 postoperative *inferior vena caval thromboses* (CVT), all originating at the lower vena caval anastomosis. The only survivor was the child retransplanted promptly for both CVT and PVT.

CVT occurred in two patients in which performance of lower vena caval anastomosis had been performed under poor technical conditions.

All but one venous complications occurred in pediatric recipients.

Budd-Chiari Syndrome

The 6 women with this diagnosis were 16-40 years old (mean 26.1 y ± 8.9). One patient died of infection 24 days postoperatively, but the other 5 had prolonged survival. One died at 452 days of recurrent Budd-Chiari syndrome, after anticoagulant therapy was discontinued in preparation for a closed liver biopsy (18) ; another death after 20 months occurred a few days after retransplantation for chronic rejection.

The other 3 patients are alive after 2, 2,5 and 6 years. The survival of half of the patients was gratifying because of the great technical difficulties encountered in all 6 cases. Two of the patients previously had undergone side-to-side portacaval shunts which had to be taken down at the time of transplantation, 2 others had extensive thromboses of the portal vein and infe-

rior vena cava which required thrombectomy. All surviving patients are still being carefully managed with Coumadin after transplantation.

Discussion

Surgical technical complications remain an important cause of morbidity and mortality after orthotopic liver transplantation (Table IV) (4, 6).

Throughout the development of OLT, the biliary tract reconstruction has always been responsible for the most technical complications (10, 15, 16, 17, 24, 31). Many of the problems encountered in the early years of liver transplantation can be traced to the use of inappropriate techniques (14, 22) and delay in recognition and treatment of complications (22, 23).

With growing experience, biliary tract reconstruction became standardized. Direct duct to duct reconstruction over a T-tube (CC-T) or Roux-en-Y choledocho-jejunostomy over an internal stent (RYCJ-S) are nowadays the preferred methods of reconstruction (11, 24). Together, these methods were successful in 305 or 334 grafts (91,3%). Similar good results have been reported recently in two smaller series (10, 31). CC-T is an ideal method of reconstruction in the recipient with a normal native bile duct ; the technique is simple and preserves the sphincter of Oddi. The T-tube stent protects the bile duct from leakage and stricture and provides easy access for diagnostic studies. The exit site of the T-tube should be at least 5 mm from the transection margin of the recipient bile duct to prevent necrosis of the intervening segment and contralateral to the neighboring vascular anastomoses to minimize the risk of biliary-vascular fistula. The T-tube is clamped as soon as liver function permits (total bilirubin < 2-3 mg/dl). Cyclosporine absorption usually improves with clamping of the T-tube and adjustments in dosage may be required. The T-tube is left in place for 2 to 3 months after surgery.

Early recognition of bile leakage or obstruction after CC-T permits prompt treatment with minimum morbidity or mortality.

The T-tube exit site is a frequent site of leaks and can often be managed by primary repair. Anastomotic leaks are more dangerous and are usually best treated by conversion to RYCJ-S.

Obstruction is a less frequent complication, can occur early or late, and may be caused by ischemic stricture, severe size discrepancy between donor and recipient ducts, errors in surgical technique, or functional obstruction by the T-tube. Percutaneous dilatation has been of temporary benefit in a few cases, conversion to RYCJ-S is usually necessary.

If the recipient duct is diseased, absent, too short or too small, or if the graft duct cannot accept a T-tube, end to side choledocho-jejunostomy over an internal polyethylene catheter stent to a Roux-en-Y limb of proximal jejunum (RYCJ-S) is the best alternative and has been, the most reliable method of biliary reconstruction (94,8% success). The most frequent complication of this method, functional obstruction of the biliary tree by a retained stent, has little morbidity or mortality, but may necessitate surgical removal of the stent.

Duct to duct repair over an internal stent is a tempting alternative when either the bile duct of the graft or the recipient is too small to accept a T-tube. However, this method is associated with a high rate of serious complications (45,3%) and RYCJ-S should be performed instead.

Most biliary tract complications occur in the first weeks after transplantation and the differential diagnosis includes rejection, hepatic artery thrombosis with secondary biliary tract ischemic injury (29), and primary graft dysfunction. Ultrasound examinations may detect duct dilatation and intra- or extra-hepatic collection but a negative study in unreliable. T-tube, ERCP, or percutaneous cholangiography can demonstrate obstruction or bile fistula (32). Even small, asymptomatic bile leaks merit prompt repair since peritonitis and infection of vascular anastomoses are significant risks.

Bile cast syndrome (23) with sludge precipitation throughout the biliary tree occurred in one case in this series. An unrecognized partial obstruction was suspected but could not be proven. During the early postoperative period there was no evidence of allograft rejection, sepsis, or drug toxicity. Retransplantation was performed successfully after 3 months. It is possible that early bile sludge is the result of an ischemic injury of the bile mucosa.

Interruption of the arterial blood supply of the liver graft is the second most frequent and the most dreadful complication of OLT (4, 6, 29). The transplanted liver is indeed at disadvantage compared with the native organ in that it lacks the collaterals that normally exist in the attachments of the liver and in that it undergoes adverse effects on bloodflow due to rejection (1, 7). Both elements render the graft ischemic and vulnerable to invasion by intestinal-micro-organisms.

The principal consequence of HAT is an ischemic injury of the intra- and/or extra-hepatic bile ducts (10, 11). The arterial supply of the biliary duct is indeed

dependant on the hepatic artery. Eight of the 25 patients (32%) having a HAT presented with a bile duct necrosis.

If the extrahepatic duct is involved, biliary leakage occurs. In case of intra-hepatic duct involvement, formation of hepatic abscess is common. The necrosis of the bile duct epithelium, followed by a dispersion of the bile into the ischemic hepatic tissues, is responsible for the formation of biloma seen on cholangiography and/or CT-scan.

The important mortality of HAT (64%), even with retransplantation (55,5%), is explained by a delay in diagnosis, responsible for treatment under unfavorable, mostly septic, conditions (21). Therefore one should be aware of the different types of clinical presentation of liver graft dearterialisation, namely fulminant liver necrosis, delayed bile leakage and relapsing bacteremia (24). The diagnosis, when suspected, must be confirmed by arteriography and Doppler flow ultrasonography (32).

HAT must be differentiated from primary graft failure, primary biliary tract complication, intra-abdominal abcedation and other undetected sources of persistant infection (4, 29).

Patients with complex vascular reconstructions and pediatric patients should especially be screened for HAT as they have the highest risk to develop the complication (13).

Because of its dramatic consequences, prevention of HAT should be aimed at. Simple allograft arterialisation in case of complex arterial recipient and/or donor hepatic supply using f.i. the fold-over technique (4, 19), prophylactic anticoagulation in very small recipients and omitting overcorrection of coagulation disorders before graft implantation have to be seen in this context. When diagnosed, HAT must be treated urgently.

Percutaneous transhepatic catheter manipulation can be useful in temporary draining of intrahepatic collections or dilating bile duct strictures but retransplantation nearly always represents the final solution for HAT. Nineteen (23,7%) of the 80 re-OLT in these series were performed because of HAT ; however 10 of the 18 retransplanted recipients died (55,5%).

Children and adolescents appear to tolerate HAT more readily than older patients, because they are better able to develop hepatopedal arterial collaterals (6, 22, 32). Only in these patients, presenting with stable LFT and controled relapsing bacteremia, a decision to delay the re-OLT may be considered.

Mycotic aneurysms and pseudoaneurysms, diagnosed by CT-scan or ultrasound, may have a similar clinical presentation as HAT. Retransplantation or aneurysmal repair have to be realised urgently in order to avoid fatal aneurysmal rupture.

About one in 5 of the liver recipients had an abnormal portal and caval vein (57/313 pat − 18%) ; in children with biliary atresia the incidence of venous anomalies has been 1 in 4 (9, 11). Acquired anomalies of PV are frequent after previous portal hypertension (8/21 pat : 38%) and hepatic (2/7 pat − 25%) surgery.

The high incidence of portal vein hypoplasia in biliary atresia patients is probably due to shunting of blood away from the portal vein via collaterals established in the adhesions caused by portoenterostomy at an earlier age.

Three patients died during OLT as a consequence of a superior vena cava anomaly (1 pat.) and of a difficult dissection of a previous portacaval shunt (2 pat.). As these venous modifications may significantly jeopardize the technique of OLT, all patients being considered for hepatic transplantation routinely undergo ultrasound examination. In the event of ambiguous findings or if the portal vein is not visualized or was thought to be thrombosed, a selective angiography or transhepatic portography to demonstrater the portal vein is mandatory. Inferior vena cavography was occasionally performed (8).

One of the most disastrous mistakes that can be made in liver transplantation is to begin to sew the new liver in without having prepared adequate venous cuffs. Early recognition of venous anomalies is therefore of utmost importance.

In case of inferior vena cava abnormalities the recipient operation is actually simpler as usual.

In case of portal vein thrombosis or hypoplasia, OLT may be possible by dissecting back the abnormal vessel to the junction of splenic and superior mesenteric veins. Sometimes the use of free vessel grafts may be necessary in order to span the distance from the more proximal recipient vessel to the hepatic allograft portal vein.

Postoperative inferior caval and portal vein thromboses are rare and occur mostly in pediatric recipients. Most of them are due to technical failures such as vessel discongruency, misalignement or rotation of the vessels.

Reappearance of portal hypertension in the presence of normal liver function can be treated conservatively, prompt retransplantation is necessary in case of liver failure.

Inferior caval vein thrombosis can only be cured with retransplantation as it was always associated with poor liver function.

Although the Budd-Chiari syndrome is a veno-occlusive disease, 5 of the 6 recipients had long survivals without recurrent disease.

OLT is an attractive, alternative therapy for this disease. Extensive thrombectomy of caval, ileo-femoral, renal and portal veins may be necessary during the transplant procedure. Chronic anticoagulation therapy is necessary to prevent lethal recurrence of the disease (18).

Résumé. Complications de la transplantation hépatique. 393 transplantations hépatiques orthotopiques (OLT) furent réalisées chez 313 patients consécutifs durant l'ère de cyclosporine-stéroïdes allant du 1 mars 1980 au 31 décembre 1984.

Les complications techniques furent responsables d'une morbidité (41/393 perte du greffon = 10,4%) et d'une mortalité (26/313 patients décédés = 8,3%) importantes.

Présentation, incidence, traitement et évolution des différentes complications biliaires, artérielles et veineuses de l'OLT sont discutées en détail.

Samenvatting. Complicaties van levertransplantaties. Gedurende de cyclosporine-steroïd periode 1 maart 1980-31 december 1984, werden 393 orthope levertransplantaties doorgevoerd bij 313 opeenvolgende patiënten.

Technische complicaties waren verantwoordelijk voor een belangrijke morbiditeit (41/393 greffeverlies − 10,4%) en mortaliteit (26/313 patienten − 8,3%). Voorkomen, incidentie, behandeling en evolutie van de biliaire, arteriële en veneuze complicaties na OLT werden uitvoerig besproken.

References

1. BRETTSCHNEIDER L., TONG J., BOOSE D. S. *et al.* Specific bacteriologic problems with canine orthotopic liver transplantation. *Arch. Surg.*, 1964, **107** : 822-832.

2. CALNE R. Y. A new technique for biliary drainage in orthotopic liver transplantation utilizing the gallbladder as a pedicle graft conduit between the donor and recipient bile ducts. *Ann. Surg.*, 1976, **184** : 605-609.

3. FUNG J. J., DEMETRIS A. J., PORTER K. A. *et al.* Use of OKT3 with cyclosporine and steroids for reversal of acute kidney and liver allograft rejection. *Nephron*, 1986, in press.

4. GORDON R. D., MAKOWKA L., BRONSTHER M. O., LERUT J., ESQUIVEL C. O., IWATSUKI S., STARZL T. E. Complications of liver transplantation. In : Complications of organ transplantation. Ed. Toledo-Pereyra L. H., Marcel Dekker Inc., New York, 1987, 329-354.

5. GORDON R. D., SHAW B. W. (jr), IWATSUKI S., TODO S., STARZL T. E. A simplified technique for revascularisation of liver homografts with a variant right hepatic artery from the superior mesenteric artery. *Surg. Gynecol. Obstet.*, 1985, **160** : 474-476.

6. GORDON R. D., SHAW B. W. (jr), IWATSUKI S. I., ESQUIVEL C. O., STARZL T. E. Indications for liver transplantation in the cyclosporine era. *Surg. Clin. N. Am.*, 1986, **68** : 451-458.

7. GROTH C. G., PORTER K. A., OTTE J. B. *et al.* Studies of blood flow and ultrastructural changes in rejecting and non-rejecting canine orthotopic liver homografts. *Surgery*, 1968, **63** : 658-668.

8. HAGLER N. G. III, BOWEN A., SKOLNICK M. L., VAN THIEL D. H., KHINE A. A., STARZL T. E. Ultrasound determination of portal vein patency in patients being evaluated for possible orthotopic liver transplantation. *Radiology* (in press).

9. IWATSUKI S., SHAW B. W. (jr), STARZL T. E. Liver transplantation for biliary atresia. *World J. Surg.*, 1984, **8** : 51-56.

10. KROM R. A. F., KINGMA L. M., HAAGSMA J. B., WESENHAGEN H., SLOOF M. J. H., GIPS C. H. Choledocho-choledochostomy is a relatively safe procedure in orthotopic liver transplantation. *Surgery*, 1985, **97** : 552-556.

11. LERUT J., GORDON R. D., IWATSUKI S., ESQUIVEL C. O., TODO S., TZAKIS A., STARZL T. E. Biliary tract complications in human orthotopic liver transplantation. *Transplantation*, 1987, **43** : 47-51.

12. LERUT J., TZAKIS A., BRON K., GORDON R. D., IWATSUKI S., ESQUIVEL C. O., MAKOWKA L., TODO S., STARZL T. E. Complications of venous reconstruction in human orthotopic liver transplantation. *Ann. Surg.*, 1987, **205** : 404-414.

13. LERUT J., GORDON R. D., IWATSUKI S., TZAKIS A., STARZL T. E. The hepatic artery in human orthotopic liver transplantation. *Neth. J. Surg.* (submitted).

14. MARTINEAU G., PORTER K. A., CORMAN J. *et al.* Delayed biliary duct obstruction after orthotopic liver transplantation. *Surgery*, 1972, **72** : 604-610.

15. NEUHAUS P., BROLSCH C. R., RINGE B., LAUCHART W., PICHYLMAYR R. Results of biliary reconstruction after liver transplantation. *Transplant Proc.*, 1984, **16** : 1225-1227.

16. ROLLES K. Early biliary tract complications. CALNE R. Y., eds. Liver transplantation. Grune and Stratton, London, 1983, 319-326.

17. SCUDAMORE C. H. Late biliary tract complications. CALNE R. Y., eds. Liver transplantation. Grune and Stratton, London, 1983, 327-341.

18. SELTMAN H. J., DEKKER A., VAN THIEL D. H., BOGGS D. R., STARZL T. E. Budd-Chiari syndrome recurring in a transplanted liver. *Gastroenterology*, 1983, **84** : 640-643.

19. SHAW B. W. (jr), IWATSUKI S., STARZL T. E. Alternative methods of hepatic graft arterialization. *Surg. Gynecol. Obstet.*, 1984, **159** : 265-272.

20. SHAW B. W. (jr), IWATSUKI S., BRON K., STARZL T. E. Portal vein grafts in hepatic transplantation. *Surg. Gynecol. Obstet.*, 1985, **161** : 66-68.

21. SHAW B. W. (jr), GORDON R. D., IWATSUKI S., STARZL T. E. Retransplantation of the liver. *Sem. Liver Disease*, 1986, **5** : 394-401.

22. STARZL T. E., ISHIKAWA M., PUTNAM C. W. *et al.* Progress in and deterrents to orthotopic liver transplantation, with special reference to survival, resistance to hyperacute rejection, and bile duct reconstruction. *Transplant. Proc.*, 1974, **6** : 129-135.

23. STARZL T. E., PUTNAM C. W., HANSBROUGH J. F., PORTER K. A., REID H. A. S. Biliary complications after liver transplantation : with special reference to the biliary cast syndrome and techniques of secondary duct repair. *Surgery*, 1977, **81** : 212-221.

24. STARZL T. E., IWATSUKI S., VAN THIEL D. H., GARTNER J. C., ZITELLI B. J., MALATACK J. J., SCHADE R. R., SHAW B. W. (jr), HAKALA T. R., ROSENTHAL J. T., PORTER K. A. Evolution of liver transplantation. *Hepatology*, 1982, **2** : 614-636.

25. STARZL T. E., HAKALA T. R., SHAW B. W. (jr), HARDESTY R. L., ROSENTHAL J. T., GRIFFITH B. P., IWATSUKI S., BAHNSON H. T. A flexible procedure for multiple cadaveric organ procurement. *Surg. Gynecol. Obstet.*, 1984, **158** : 223-230.

26. STARZL T. E., IWATSUKI S., SHAW B. W. (jr). A "growth factor" in fine vascular anastomoses. *Surg. Gynecol. Obstet.*, 1984, **159** : 164-165.

27. STARZL T. E., IWATSUKI S., SHAW B. W. (jr), GORDON R. D., ESQUIVEL C. O., TODO S., KAM I., LYNCH S. Factors in the development of liver transplantation. *Transplant. Proc.*, 1985, **17** (suppl. 2) : 107-119.

28. Starzl T. E., Iwatsuki S. I., Esquivel C. O., Todo S., Kam I., Lynch S., Gordon R. D., Shaw B. W. Refinements in the surgical technique of liver transplantation. *Seminars in Liver Disease*, 1985, **5** : 349-356.

29. Tzakis A. G., Gordon R. D., Shaw B. W. (jr), Iwatsuki S., Starzl T. E. Clinical presentation of hepatic artery thrombosis after liver transplantation in the cyclosporine era. *Transplantation*, 1985, **40** : 667-671.

30. Waddell W. R., Grover F. L. The gallbladder as a conduit between the liver and intestine. *Surgery*, 1973, **74** : 524.

31. Wolff H., Otto G., David H. Biliary tract reconstruction in liver transplantation. *Transplant. Proc.*, 1985, **17** : 274-275.

32. Zajko A. B., Campbell W. L., Bron K. M., Lecky J. W., Iwatsuki S., Shaw B. W. (jr) and Starzl T. E. Cholangiography and interventional biliary radiology in adult liver transplantation. *Am. J. Radiology*, 1985, **144** : 127-133.

J. Lerut
Torsinplein, 15
B-3300 Tienen, Belgium