Transpl Int (1994) 7: 297–301

ORIGINAL ARTICLE

J. Lerut
R. Reding
J. de Ville de Goyet
A. Baranski
A. Barker
J. B. Otte

Technical problems in shipped hepatic allografts: the UCL experience

Received: 16 May 1993
Received after revision: 10 August 1993
Accepted: 30 September 1993

J. Lerut (✉)[1] · R. Reding · J. de Ville de Goyet · A. Baranski · A. Barker · J. B. Otte
Department of Digestive Surgery, University Hospitals St-Luc, Catholic University Louvain, Brussels, Belgium

[1] *Mailing address:* Service de Chirurgie Digestive – 1401, Cliniques Universitaires Saint-Luc, Avenue Hippocrate 10, B-1200 Brussels, Belgium Fax: 32-2-762.36.80

Abstract Due to developments in surgical techniques and organ preservation, the shipping of renal and extrarenal organs is becoming increasingly more frequent. During the period from 1 January 1991 to 31 December 1992, 39 of 180 (21 %) implanted liver allografts were shipped to our center by local harvesting teams. The fact that each of nine livers (23.1 %) presented with minor and major (vascular and parenchymatous) problems stresses the need for better surgical training and standardization in procurement techniques. The introduction of a liver allograft feedback report could be an easy way to perform quality control.

Key words Liver transplantation, shipped · Shipped livers, complications

Introduction

Growing experience with solid, and especially extrarenal, organ transplantation has steadily raised the costs of medical care. The shipping of organs for transplantation is costly in more ways than one. Yet, if the procurement of extrarenal organs were to be done exclusively by local teams, not only would fewer organs be lost but the costs of transplantation related to long-distance travelling by harvesting teams would also be reduced. This paper discusses our experience with 39 liver allografts shipped to our center.

Materials and methods

In order to obtain a representative idea of the actual situation, only grafts shipped during the period from 1 January 1991 to 31 December 1992 were taken into consideration. During this period, 180 orthotopic liver transplantations were performed by the Department of Surgery of the University Hospital Saint-Luc in Brussels. Thirty-nine (21 %) of the implanted grafts were procured by the local teams and shipped to us. There were 22 contributing centers: Groningen, Maastricht, Rotterdem, Paris Bicêtre, Berlin, Essen, Erlangen, Hannover, Heidelberg, Munich, Innsbruck, Vienna, Oslo, Barcelona, Antwerpen, Brussels, Gent, Leuven, Liège, Geneva, Tel Aviv, and Cambridge.

In four cases, the liver and the total pancreatoduodenal grafts were used by different centers for implantation; in three cases the liver allograft was a split-liver graft. All livers were harvested using "classical" procurement techniques, although the extent of abdominal organ dissection varied widely. All livers were rinsed and preserved with University of Wisconsin solution.

Technical problems encountered in shipped allografts were divided into major and minor ones. We considered a problem as major when it had major impact on the implantation procedure itself.

Results

Problems of logistics were rather infrequent: one recipient operation had to be organized while organ procurement was underway and another, after the organ had been procured. Both recipient operations were uneventful.

The median ischemia times for shipped and non-shipped allografts were 11.38 h (range 5.14–26 h) and 13.35 h (range 6.2–21.50 h), respectively.

The absence of gallbladder and bile duct flush, the absence of vascular grafts (venous and arterial), and lesions of the bile ducts were considered as minor technical prob-

Table 1 Minor technical problems in 39 shipped liver allografts

Problem	Number of cases	Treatment
No vascular grafts	5	Hepatic artery thrombosis (bile duct reconstruction)
No biliary tract flush (at all)	3	Primary nonfunction leading to death Early nonfunction (reOLT) High hepatic duct resection
High hepatic duct transection	1	
	9 of 39 grafts (23.1 %)	

Table 2 Arterial problems in shipped liver allografts

Problem	Number of cases	Treatment
High transection hepatic artery	1	Iliac graft reconstruction
Transection right and left hepatic artery	1	Iliac graft reconstruction
Transection right hepatic artery superior mesenteric artery	1	Splenic arterial reconstruction
Right hepatic artery ←superior mesenteric artery	1	Planned split cancelled → reduced-size graft
Right hepatic artery ←superior meserior artery	1	Gastroduodenal arterial reconstruction
Detection of major intimal flap (tear) in hepatic artery	1	High resection of vessel
	6 of 39 grafts (15.4 %)	

Table 3 Venous problems in shipped allografts

Problem	Number of cases	Treatment
Portal vein lesion	1	Suture
Caval vein lesion		
– too short infrahepatic IVC with acc. hepatic vein transection	1	Tubulization IVC
– no suprahepatic IVC with left hepatic vein lesion	1	Piggyback implantation
	3 of 39 grafts (7.7 %)	

lems. There were at least nine (23.1 %) such *minor technical problems* (Table 1).

There were no vascular grafts accompanying at least five of the grafts. From the operative records, at least five patients needed an arterial iliac graft for rearterialization. Arterial grafts from the arterial homograft bank were used in four cases (grafts from previous donors are preserved for a period of 2–3 weeks in Terasaki tissue cell culture medium). For one patient no arterial graft was available, so a difficult direct end-to-end anastomosis between the celiac trunks of the donor and the pediatric recipient was performed. This anastomosis led to hepatic artery thrombosis that was later complicated by the development of biliary strictures. This necessitated bile duct reconstruction.

In three grafts, neither the gallbladder nor the biliary tract was flushed: one recipient developed primary nonfunction and later died of this complication. Another patient had severe early liver dysfunction, leading to retransplantation. This patient later died of multiorgan failure. On one occasion necrosis of the common bile duct mucosa was detected during back-table preparation. The bile duct was resected up to the healthy bifurcation. In one case the hepatic duct had been transected near the main bifurcation. The biliary tract was reconstructed with a hepaticojejunostomy.

Major technical problems were encountered fourteen times in nine livers (9 of 39 livers; 23 %). There were six arterial, five capsular and parenchymatous, and three venous lesions. All six arterial problems (6 of 39 grafts; 15.4 %) were related to technical problems (Table 2). In two cases, the hepatic artery was transected very close to the hilum; both transections were repaired by iliac graft reconstruction. In three cases the right hepatic artery originating from the superior mesenteric artery was transected; different arterial reconstructions using the splenic and gastroduodenal arteries were successful. In one case, we detected a major intimal flap of the common hepatic artery during back-table work, probably due to a tear in this artery during procurement. This problem was resolved by transection of the hepatic artery above the intimal flap. One planned split graft had to be cancelled because of a lesion of the unique right hepatic artery originating from the superior mesenteric artery.

Venous problems in shipped allografts were rare (3 of 39 grafts; 7.7 %; Table 3). Once, a large laceration high up in the portal trunk was repaired by suture. In two cases, a major lesion of the caval vein was present; an intrahepatic vena cava transection immediately to the liver and a major accessory hepatic vein transection were resolved by inferior vena cava (IVC) tubulization. In one case, the suprahepatic IVC cuff was absent; moreover, there was a lesion of the left hepatic vein (Fig. 1). This problem was resolved by piggyback implantation using laterolateral cavostomy.

Capsular and parenchymatous problems were a major concern. They were present in 5 of 39 grafts (12.8 %; Table 4). Decapsulation of the right hepatic dome caused intraoperative as well as major postoperative bleeding necessitating relaparotomy. One decapsulation was accompanied by a severe parenchymatous lesion of the right liver that caused severe bleeding. This made retransplantation necessary.

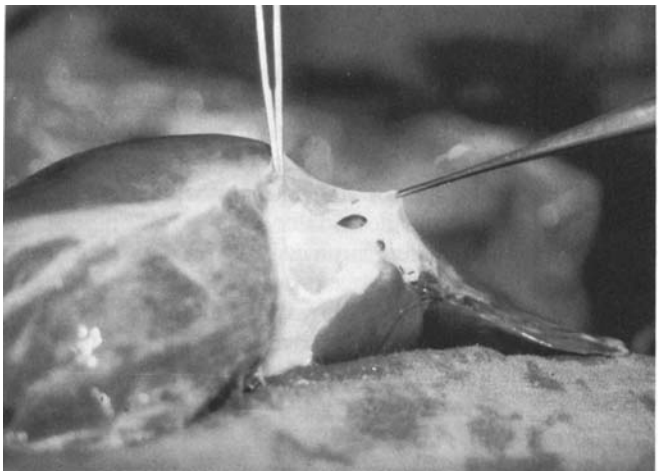

Fig. 1 Although the necroliver report mentioned "long suprahepatic caval cuff", no cuff was present but there was a lesion of the left hepatic vein

In one case, major decapsulation of the inferior surface of the right liver was responsible for severe intraoperative bleeding that could only be controlled by packing. Severe bleeding and major steatosis were responsible for severe early dysfunction, necessitating retransplantation. Unfortunately, the second liver for this patient was also damaged by decapsulation and there was a severe parenchymatous lesion of the right liver. The operation was very hemorraghic. The patient died later due to multiorgan failure.

It should be stressed that there was no information at all on the necroliver report about these capsular and parenchymatous lesions in four patients. Once, a superficial tear in the capsule was mentioned. This was an 8-cm long and deep parenchymatous lesion.

There was no difference in the incidence of primary nonfunction in shipped or locally harvested livers (1 of 39 vs 2 of 141 grafts).

Only 1 of the 141 grafts (0.7%) procured and implanted by our transplant team presented a major technical problem, namely, a transection of a right hepatic artery just above where it exited the superior mesenteric artery.

Discussion

The introduction of University of Wisconsin solution allows secure preservation of liver grafts for 18 h and, hence, increased clinical activity in solid organ transplantation. This makes the shipping of allografts increasingly necessary [3, 12]. Harvesting by local, well-trained surgical teams may solve many of the organizational and economical problems of organ grafting [6–8]. Indeed, the crowding of operating rooms by various foreign teams has been responsible not only for the loss of organs, but also for a lack of sustained interest by local teams in organizing procurements. Harvesting by local teams would, moreover, allow for organ transport by more regular means, such as commercial aircraft and rapid ground traffic [8].

One must not assume that a reluctance to import hepatic allografts stems from fear of ischemic damage or primary nonfunction. As found by other teams and confirmed in the present study, the incidence of primary nonfunction was no higher in imported hepatic allografts than it was in locally procured ones [7, 19].

The experience gained during the past 2 years in our center shows that there is a need not only for training in procurement techniques, but also for continuous quality control by the procurement teams (despite the fact that liver procurement and implantation are common surgical practice in many hospitals).

Although livers were exchanged between 23 centers (including Eurotransplant, UK, France, Spain, and Scandia Transplant), major logistical problems were not encountered. This emphasizes the professionalism developed by the various transplant organizations [6].

Improvements can be made in surgical techniques. Indeed, too many major life-threatening problems are registered. Rapid and simple standardized procurement techniques, e. g. the one developed in our department, should be more widely adopted by other teams [9, 12, 14, 19]. The procurement of various thoracic and abdominal organs by one thoracic and one abdominal surgeon would greatly simplify the organization of the procedure [11]. Such procurement techniques are less time-consuming, interfere less with local hospital arrangements, and favor collaboration between centers.

Transplant and procurement surgeons should be more attentive to arterial problems [7, 16]. Many different arterial vascularization patterns of the liver exist, especially anomalies of the right hepatic artery. This should be kept

Table 4 Capsular parenchymatous problems in shipped liver allografts

Problem	Number of cases	Treatment
Decapsulation of right hepatic dome	1	Bleeding controlled by packing
Decapsulation of right and left liver lobes	1	Relaparotomy (bleeding)
Decapsulation and severe parenchymatous lesion of right liver	1	Severe bleeding (reOLT)
Decapsulation of inferior surface – right liver	1	Severe bleeding controlled by packing
Decapsulation and severe parenchymatous lesion of right liver	1	Severe bleeding →death
	5 of 39 (12.8%) grafts	

No or incomplete information in the necroliver report 4 and 1 grafts respectively.

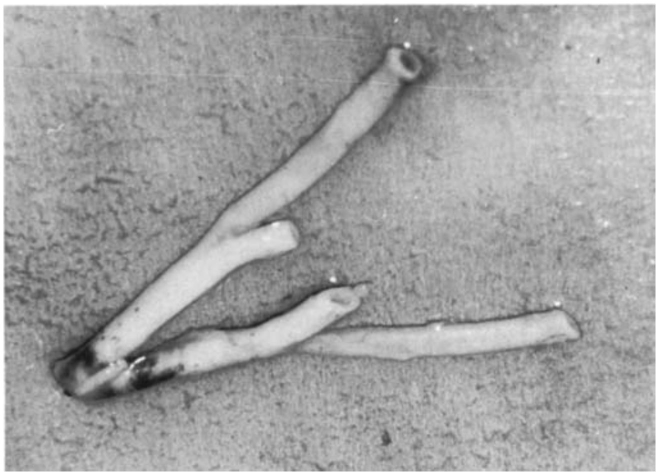

Fig. 2 Correct iliac arterial graft procurement including common iliac and complete external ilial artery. The size of the external ilial artery usually matches both the size of the adult coeliac trunk and the size of the infrarenal abdominal pediatric aorta well

in mind. If arterial lesions are present, they must be mentioned immediately to the transplant surgeon so that vascular reconstruction, even using microvascular back-table techniques if necessary, can be used in order to save the graft.

During back-table work, intraluminal inspection of the artery must be done systemically; endoscopic control may be of use if doubt exists [18].

Venous problems should not occur. Suprahepatic or intrahepatic IVC cuffs that are too short do not preclude graft implantation. Adapted piggyback implantation techniques, using, for example, laterolateral cavocavostomy and tubulization of the lower part of the IVC by ligating several short hepatic veins draining segment I, allow safe implantation [1, 10].

Many times revascularization of the graft necessitates the use of free vascular allografts [13]. During procurement, iliac venous and arterial bifurcations should be harvested. If possible, jugular veins and carotid arteries should also be harvested. When being procured iliac arteries should be taken from the aorta iliac bifurcation to the inguinal ligament (Fig. 2). This is of utmost importance in pediatric transplantation. In fact, the diameter of the (adult) external iliac artery is ideal for anastomosis to the pediatric coeliac trunk or the infrarenal abdominal aorta.

The gallbladder and biliary tract should be systematically well flushed during procurement [14]. It has been shown, during the initial experience of liver grafting, that the precipitation of bile salts may destroy the biliary mucosa [4]. Flushing of the gallbladder is often insufficient. Indeed, the cystic duct frequently joins the bile duct at a point distal to the bile duct transection [2]. Cannulation and flushing of the common bile duct by a small catheter is, therefore, necessary and can be performed at the end of the procurement. If a liver graft has been shipped without flushing, the bile duct must be carefully inspected in order to detect mucosal damage. It may be necessary to resect the common bile duct higher up.

Capsular and parenchymal lesions of the liver should be avoided at all times during harvesting. One should pay attention to the hepatorenal ligament and to adhesions between the liver capsule and the diaphragm. These structures should be divided cautiously by electrocautery [14] at the beginning of the intervention.

If capsular tears occur, they must be mentioned to the transplant surgeon. Although liver procurement has been reported in donors who have had previous upper abdominal surgery, one should pay particular attention to decapsulation of the liver in such donors [15]. Deeper parenchymatous lesions must be carefully managed during back-table work. If parenchymatous lesions cause major intraoperative bleeding, this may be controlled with the packing techniques described for liver trauma [5]. Appli-

Table 5 Proposed necroliver feedback report

Date:		Time:
DONOR SURGEON:		Donor Hospital: Tel.: Fax: Coordinator:
RECIPIENT SURGEON:		Recipient Hospital: Tel.: Fax: Coordinator:
DONOR NUMBER		
Name:		Date of birth:
Body weight:		Height:
Cause of brain death:		Sex M/F:
Brain death date:	Bloodgroup	O/A/B/AB
Bili T/D:	Alc. Phos.:	GGT:
ASAT/ALAT	LDH:	
CMV IgG/IgM:	HBsAg:	HIV:
HCV-Ab:	Lues:	
PROCUREMENT		
Cold perfusion:	Time start: Type fluid: UW/EC/HTK Vol. used:	
Technique:	Aortic single flush/Combined aortic and portal flush/En bloc technique Isolated liver/Combined hepato-pancreatic	
QUALITY OF PERFUSION:	good/bad	Lavage bile duct: yes/no
Particularities:	Vasc. art./ven. graft: yes/no	
Macroscopic abnormalities:	– parenchyma: laceration/lesion/steatosis – veins: hepatic: – arteries: – biliary tract:	 portal:
SHIPMENT		
Organized by donor/recipient center		with/without problems
IMPLANTATION		
Reperfusion:	excellent/good/bad	
Bile production:	immediately/retarded	
Bile quality:	good/bad	
Lowering lactic acid:	yes/no	Immediately/delayed
Liver biopsy: steatosis:	yes/no	Estimation: %

cation of a plastic sheet to the traumatized area will allow the perihepatic packing to be removed easily some days later. If the parenchymatous lesions are too severe, the liver should either be discarded for liver grafting or a reduced-size liver graft prepared, excluding the traumatized area; this may avoid graft loss [10].

Speaking from this experience, we can say that the shipping of liver allografts is responsible for neither enhanced allograft dysfunction nor major logistical problems. Too many (major) technical mishaps are still encountered; they stress the need for standardization and simplification of procurement techniques and for the appropriate training of procurement surgeons. Moreover, necroliver reports are not used often enough as a communication tool between the different transplant centers.

The procurement of extrarenal organs should be performed by the surgeon as if the organs were to be used in his own center. If doubt exists about the quality of an organ, one should not hesitate to perform multiple bilobar biopsies (this expecially to exclude major steatosis and hepatitis [17]); one should also cancel the procedure if intraoperative findings indicate a possible compromise of graft function (gross abnormalities, etc.). If technical problems are encountered, the recipient transplant surgeon should be notified immediately by phone or fax in order to allow adequate measures to be taken.

Correct and completed necroliver reports, together with written feedback reports (Table 5) about the liver allografts, should be sent to the transplant procurement organizations within 24 h of implantation. This would not only allow a better exchange of liver allografts, but would also enhance the confidence of the various surgical teams in one another. Serious technical shortcomings should, ideally, be documented with photographic illustrations (Fig. 1).

Our experience with shipped allografts clearly emphasizes the need for adequate surgical training of procurement surgeons. A list of "accredited surgeons" for each center (coordinated by the different European transplant organizations) should be made and sent to the various cooperating centers. Such measures would guarantee the exchange of high-quality organs that could be transported by regular, commercial aircraft in order to substantially reduce the costs of the procurement.

Acknowledgements A. B. is supported by the P. F. Sobotka postgraduate scholarship from the University of Western Australia.

References

1. Belghiti J, Sauvanet A, Panis Y, Gayer B, Fekete F (1992) A new technique of side-to-side caval anastomosis during orthotopic liver transplantation without inferior vena caval occlusion. Surgery 175: 271–272
2. Belzer FO, D'Alessandro AM, Hoffman RM, Kalayoglu M, Sollinger H (1992) Management of the common duct in extended preservation of the liver. Transplantation 53: 1166–1167
3. Belzer FO, D'Alessandro AM, Hoffman RM, Knechtle SJ, Reed A, Pirsch JD, Kalayoglu M, Sollinger HW (1992) The use of UW-solution in clinical transplantation. Ann Surg 6: 579–585
4. 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 186: 282–290
5. Carmona RH, Peck DZ, Lim RC (1984) The role of packing and planned reoperation in severe hepatic trauma. J Trauma 24: 779–784
6. Deboer J (1992) From mistake to disaster. Eurotransplant Newsletter No. 100 pp 4–6
7. Jonas S, Bechstein WO, Keck H, Blumhardt G, Lemmens HP, Neuhaus P (1993) Transplantation of shipped donor livers. Transpl Int 6: 206–208
8. Langas AN, Duckworth RM, Stratta RJ, Shaw BW (1990) Imported hepatic allografts: a single center experience. Transplant Proc 22: 414–415
9. Nakazato P, Concepcion W, Bry W, Limm W, Tokunaga Y, Itasaka H, Feduska N, Esquivel CO, Collins G (1992) Total abdominal evisceration: an en-bloc technique for abdominal organ harvesting. Surgery 111: 37–46
10. Otte JB, Ville de Goyet J de, Sokal E, Alberti D, Moulin D, Hemptinne B de, Veyckemans F, Obberg L van, Carlier M, Clapuyt P, Claus D, Jamart J (1990) Size reduction of the donor liver is a safe way to alleviate shortage of size-matched organs in pediatric liver transplantation. Ann Surg 211: 146–157
11. Sanchez-Urdazpal L, Gores GJ, Ward EM, Maus TP, Wahlstrom HE, Moore SB, Wiesner RH, Krom RAF (1992) Ischemic-type biliary complications after orthotopic liver transplantation. Hepatology 16: 49–53
12. Starzl TE, Demetris AJ (1990) Liver transplantation: a 31-year perspective. Year Book Medical, Chicago
13. Starzl TE, Halgrinson CG, Koep IJ, Weil R, Taylor PD (1979) Vascular homografts from cadaveric organ donors. Surg Gynecol Obstet 149: 76–77
14. Starzl TE, Miller C, Broznick B, Makowka L (1987) An improved technique for multiple organ harvesting. Surg Gynecol Obstet 165: 343: 348
15. Stratta RJ, Hoffmann RM, Sollinger H, Kalayoglu M, D'Alessandro A, Belzer F (1988) Successful hepatic allograft procurement and transplantation from a donor after cholecystectomy. Transplantation 46: 599–600
16. Todo S, Makowka L, Tzakis AG, Marsh JW, Karrer FM, Miller AD, Tallent MB, Esquivel CO, Gordon RD, Iwatsuki S, Starzl TE (1987) Hepatic artery in liver transplantation. Transplant Proc 19: 2406–2411
17. Todo S, Demetris AJ, Makowka L, Teperman L, Podesta L, Shaver T, Tzakis A, Starzl TE (1989) Primary non-function of hepatic allografts with preexisting fatty infiltration. Transplantation 47: 903–905
18. Tzakis A, Shapiro R, Starzl TE (1992) Backtable angioscopy to evaluate the renal artery. Transplantation 53: 1380
19. de Ville de Goyet J, Hausleitner V, Reding R, Lerut J, Otte JB (1994) Exclusive aortic cooling for quick harvesting procedure. Transplantation (in press)