Paediatric orthotopic liver transplantation : lessons from a 532 transplant single centre experience with 532 transplants in 446 children

J. de Ville de Goyet [1], R. Reding, J. Lerut, E. Sokal, M. Janssen, J.B. Otte

Department of Paediatric Surgery, Liver and Intestine Transplantation, Université Catholique de Louvain, Cliniques Saint-Luc, Brussels, Belgium ; (1) Current address : Liver Unit, Birmingham Children's Hospital, Birmingham, U.K.

(Acta gastroenterol. belg., **1999**, 62, **290-294**).

Key words : liver transplantation, child, surgical procedures, operative, postoperative complications.

Between March 1984 and December 1997, 532 orthotopic liver transplantations (OLT) were performed in 446 children at the University clinics St Luc, Brussels (1-5). This experience was retrospectively analysed with special emphasis on technical aspects and complications ; a detailed review of patient notes was performed as per May 1998, allowing a 4-month minimum follow-up for each graft.

The primary indications for liver replacement are detailed in table 1 ; there were minor changes from one year to the next in the whole experience, biliary atresia remaining the leading indication. Age and weight at transplantation ranged from 0.26 to 16.4 years old (Med 2.2 years) and 4.4 to 65 KGs (Med 10.8), respectively. 112 patients were less than 1 year old and 127 patients were less than 8 KGs at transplantation. Liver transplantation was performed under highly urgent conditions (ICU bound patient), in urgent conditions (hospital bound patient) and electively in 106, 136 and 290 cases, respectively (fig. 1).

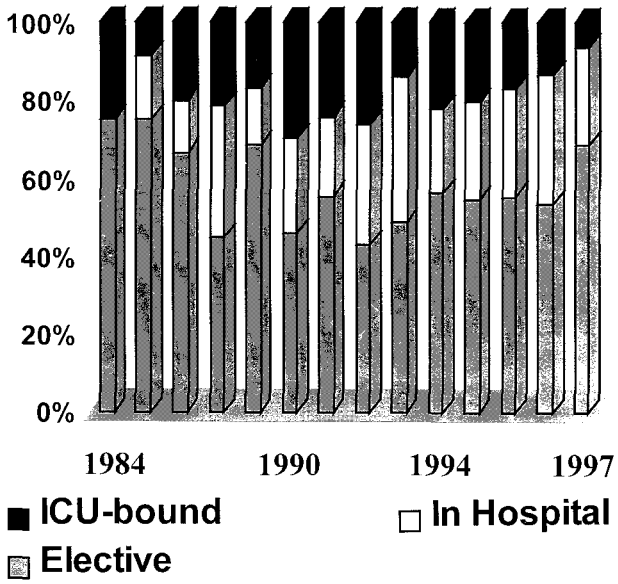

Fig. 1. — Recipient clinical status, at transplant.

Table 1. — **Primary indications for OLT**

Biliary atresia	305
Metabolic disease	53
Fulminant failure	33
Cholestasis other	27
Cirrhosis other	20
Liver tumor	8

Liver graft (LG) types were as follows : 205 full-size LG and 327 technical variants LG, being 235 reduced LG, 35 split LG and 54 LG from living related donors. Taking into account that techniques evolved with time and that LG anatomy differed subsequently, two types of reduced LG were considered for the study. In the mid and late eighties, LG were reduced by cutting-down the right hepatic segments, without hilum dissection, and the donor Inferior Vena Cava was retained with the LG (6-7) (so-called "cut-down" LG (N = 98)), consisting of segments 1 to 4 (according to Couinaud). In the early nineties, hypereduction techniques appeared, allowing the preparation of "segmental" LG (8,9) consisting of segments 2 and 3 (N = 82) or less frequently of segments 2, 3 and 4 (N = 55). As shown in figure 2, cut-down LG were replaced with segmental LG : these latter LG also tended to be replaced when living related transplants were introduced and when liver division expanded. In three patients the LG was reduced by cutting-down the left liver lobe. In one patient, portal vein thrombosis related to oversized segmental LG led us to reduce this LG further, on day 2, which resulted in a monosegmental LG (segment 2). Split liver grafts consisted of the left lobe (segments 2 + 3 ; N = 20), the left liver (segments 2 to 4 ; N = 10) or the right liver (segments 5 to 8 ; N = 5). There was a trend for increased use of technical variants with time. Division of the liver, as achieved with cadaveric donor liver splitting or with living related donors, also was introduced progressively (10,11). The introduction of living related donation in 1993 was

Correspondence to J. de Ville de Goyet, Liver Unit, Birmingham Children's Hospital, Steelhouse Lane, B4 6NH Birmingham, U.K.
Presented at the Symposium "1000 Liver Transplants at Cliniques Saint-Luc. An Update.", October 30, 1998.

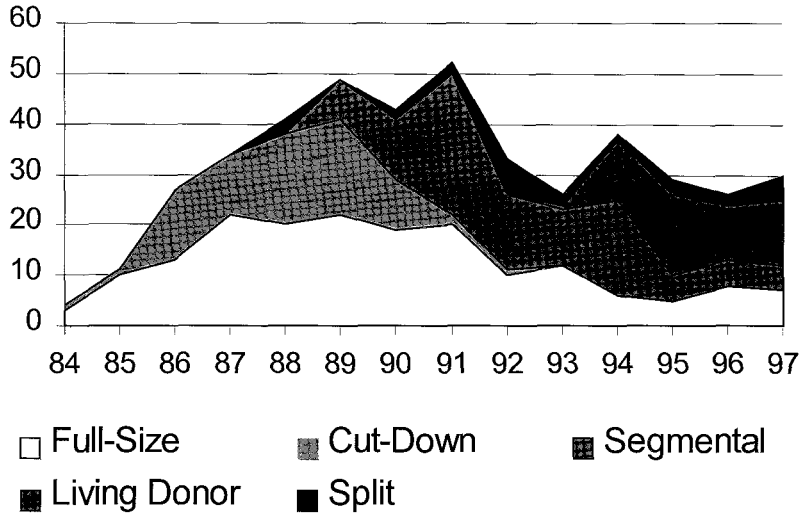

Fig. 2. — Repartition of liver graft types according time.

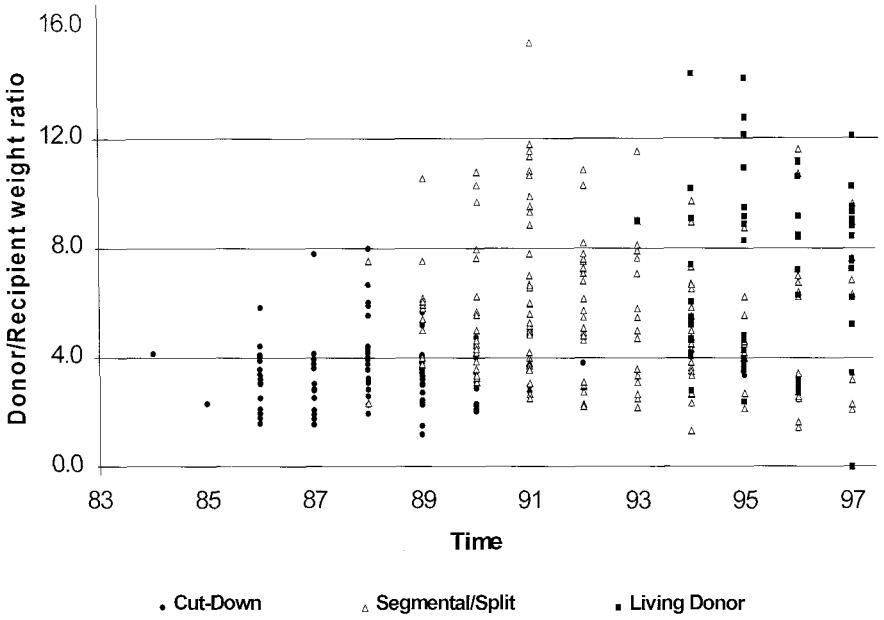

Fig. 3. — Evolution of Donor to Recipient weight ratio according techniques and time.

followed by a rapid increase, which benefited both living and cadaveric donor programs (3,4).

Technical innovations allowed the use of larger donors as shown in figure 3 : there was a trend for an increased donor to recipient weight ratio with time. The use of temporary prosthetic closure of the abdominal wall also played a contributory role in this evolution by allowing oversized LG to match the abdominal cavity when augmented with the prosthetic wall (12) (fig. 4).

The hepatic vein reconstruction was made according to the conventional techniques at corresponding times, being caval replacement before the nineties (7), then switching to retaining the native IVC and using piggyback techniques in most patients, either for full-size LG or technical variant LG implantations (8). Vascular thrombosis was rare except in the cut-down LG group (up to 10% of caval thrombosis). In this latter group, thrombosis was probably related to replacement of the native IVC with the IVC from a larger donor resulting in diameter mismatch and the need for longitudinal IVC tailoring. Budd-Chiari problems were observed in some patients, after piggyback reconstruction, mostly related with re-OLT and piggyback re-do's preserving the fibrotic ring of the previous anastomosis. These latter problems disappeared since the Chicago modified technique (Triangular piggyback) was used (13).

Hepatic artery reconstruction varied considerably with time. The major technical changes were the predominant use of vascular conduits (mostly donor iliac artery) for bridging from the infra-renal recipient Aorta, during the period 1990-1993. Further develop-

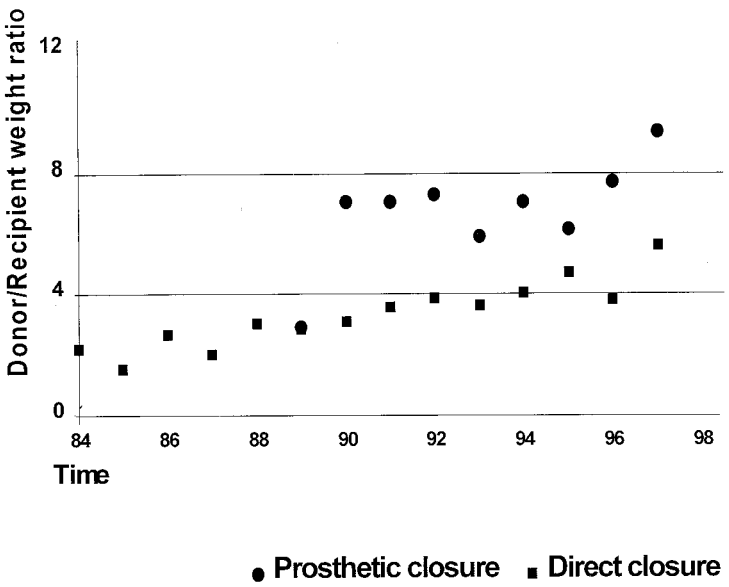

Fig. 4. — Mean Donor to Recipient weight ratio according time and with/without prosthetic abdominal closure.

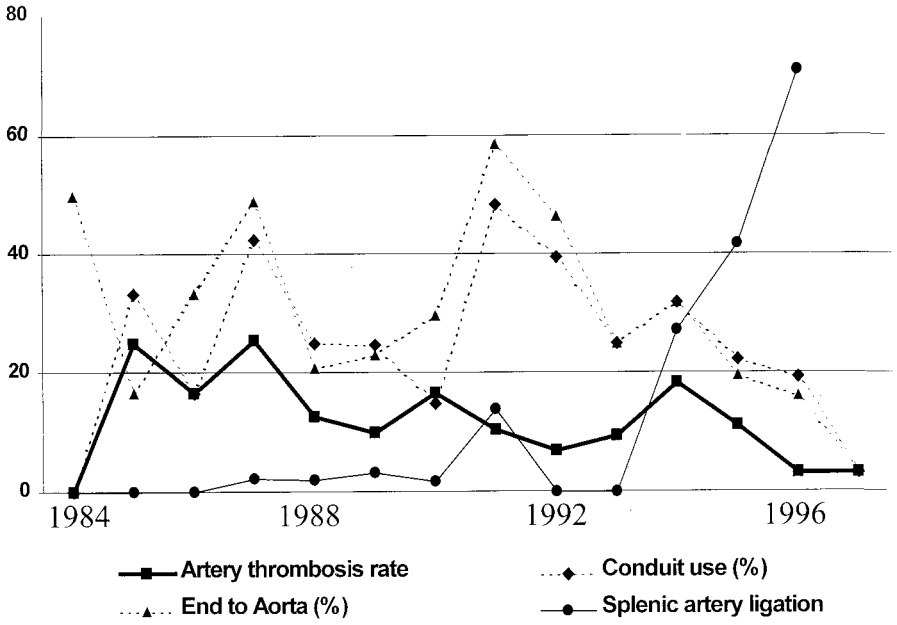

Fig. 5. — Early (< 1 month) Hepatic artery thrombosis in first liver transplants according technical changes through time (1984 to 1997).

ments after 1993 (living related donor program start) included the use of semi micro-vascular techniques (routine use of magnifying loupes × 6) for direct end-to-end reconstruction from the recipient hepatic artery and the frequent use of splenic artery ligation at OLT for increasing the arterial flow to the liver.

As it has been reported previously (1,2,14), early hepatic artery flow problems (HAP : thrombosis or no-flow) was, at least in our experience, significantly related with the use of small donors (less then 20 KGs), small diameter artery and complex vascular reconstructions. On the contrary, HAP was lower when technical variants were used as the donor weight and the donor vessel size were larger. Accordingly, HAP yearly rates decreased from 25 % to a 3% rate during the last 2 years (fig. 5). This progressive drop did not seem to be significantly related with a given technique for vascular reconstruction but rather with diverse refinements. Although the HAP rates were lower when vascular conduits were used and when LG were revascularised from the Aorta, the difference did not reach statistical significance, at least for primary transplants, when compared to conventional techniques (10.1% versus 13.3%, and 8.3% versus 14.1%, respectively). When the former reconstruction techniques were used, lower HAP rates were related more to the

use of LG from larger donors than related to the use of vascular conduits. Also the introduction of Splenic artery ligation was not associated with significant differences (table 2).

Table 2. — **Splenic Artery (SA) ligation Effect on hepatic artery thrombosis rate**

Graft type	SA tied off	SA preserved
Full-size	4/18 (22%)	31/159 (19.5%)
Reduced-size	0/3 (0%)	9/75 (12%)
Segmental	1/11 (9%)	7/97 (7%)
Split liver	1/2 (50%)	1/25 (4%)
Living donor	0/21 (0%)	1/32 (3%)

This suggested that lower HAP rates reflected increased experience. Therefore we analysed the results, according to graft types and dividing the experience in three consecutive periods of time, being the first half (1984 to 1990), then 1991 to 1993 (predominant use of vascular conduits), and 1994 to 1997 (semi micro-vascular anastomosis). Interestingly, comparison of HAP rates for each graft type did not show significant differences according to time (table 3). In fact the trend for overall lower HAP resulted from a progressive selection of the graft types with lower complication rates, as it can be concluded from combined analysis of fig. 2 and table 3.

Table 3. — **Early (> 1 month) hepatic artery flow problems* according experience and graft type**

Graft type	1984-90	1991-93	1994-97
Full-size liver	21%	17%	19%
Cut-down LG	13%	21%	—
Segmental LG	5%	6%	9%
Split LG	0%	9%	9%
Living donor	—	0%	2%

* Flow problems : thrombosis or absence of flow at Doppler US.

Our current practice for arterial reconstruction is as follows : priority for micro-vascular type anastomosis using magnifying glasses, end to end anastomosis from recipient hepatic artery, intraoperative use of US Doppler and flowmeter for assessment of graft perfusion, post-operative management based on anti-aggregant therapy, care for low-haematocrit and early detection of arterial problem with daily US Doppler (twice daily for small arteries for one week, than daily for one week and twice weekly thereafter).

Portal vein reconstruction was achieved using conventional techniques. When portal vein hypoplasia (< 4 mm) was present, adequate revascularisation was obtained by anastomosis from the recipient splenomesenteric junction or Superior Mesenteric vein ; in most of the latter cases, a venous jump graft (donor iliac vein) was interposed. When grafts procured from large donors were implanted, attention was given, at the time of closing the abdomen, to avoid mispositioning, kinking or compression of the vein (8). For that purpose, US Doppler was performed for evaluation of the portal flow during abdominal closure and tight closure was avoided whenever possible (temporary prosthetic abdominal closure (12)).

Overall, portal vein thrombosis and flow problems occurred in 7.8% of the first transplants. The incidence by graft type is detailed in table 4, showing the best results in the living donor group. Taking into account the shorter follow-up in this latter group, these results should be confirmed by long term studies. Interestingly, the more difficult positioning of the graft in segmental grafts procured from large donors was not associated with increased thrombosis rates. Complex portal reconstruction using jump grafts was associated with an increased risk of venous problems (table 5).

Table 4. — **Incidence of portal vein problem* in first transplants**

Graft type	Donor PV anastomosed to Portal vein	SMV**
Full-size	15/169 (9%)	2/8 (25%)
Reduced-size	4/75 (5%)	0/3 (0%)
Segmental	11/92 (12%)	1/16 (6%)
Split liver	1/26 (4%)	0/1 (0%)
Living donor	1/51 (2%)	0/2 (0%)

* Includes thrombosis, and non-thrombotic low-flow or non-flow problems.
** SMV : Superior Mesenteric Vein.

Table 5. — **Portal vein problems in first grafts**

Donor portal vein to	Portal vein problems	N (%)
1. Recipient portal vein		
- direct end-to-end	28/38 (7%)	
- with venous graft	4/27 (15%)	
2. Recipient superior mesenteric vein		
- direct end-to-end	0/6 (0%)	
- with venous graft	3/24 (12.5%)	

Our current policy for graft implantation is as follows : routine use of magnifying glasses, portal reconstruction from the lower portion of the portal trunk when its diameter is adequate or from the splenomesenteric junction in case of portal vein hypoplasia, intra-operative evaluation (US Doppler and Flowmeter) and avoiding tight abdominal closure, post-operative care including anti-aggregant therapy and low haematocrit, and early detection of problems by daily US Doppler.

As in other paediatric series, bile duct reconstruction with a Roux-en-Y loop was routinely used. Ischaemic type biliary problems accounted for a quarter of the problems and were accordingly influenced by the decrease in hepatic artery problems during the last years. Overall (all types) biliary problems were diag-

nosed in 22% of the first transplants. Stenting and biliary drainage were used until 1989 but were not associated with a lower complication rate, subsequently, they were abandoned.

In conclusion, the use of alternative techniques played a major role in transplantation of small children in our centre, and technical variants represented more than two thirds of the grafts during the last years. The implementation of technical modifications throughout the whole experience was a contributory factor for keeping the complication rate as low as possible, and culminated in achieving excellent technical results in the group of transplant from living related donors (3,4).

References

1. OTTE J.B., DE VILLE DE GOYET J., SOKAL E., ALBERTI D., MOULIN D., DE HEMPTINNE B., VEYCKEMENS F., VAN OBBERGH L., CARLIER M., CLAPUYT PH., CLAUS D., JAMART J. Size reduction of the donor liver is a safe way to alleviate the shortage of size matched organs in pediatric liver transplantation. *Ann. Surg.*, 1990, **211** : 38-49.
2. DE VILLE DE GOYET J., HAUSLEITHNER V., REDING R., LERUT J., JANSSEN M., OTTE J.B. Impact of innovative techniques on the waiting list and the results in pediatric liver transplantation. *Transplantation*, 1993, **56** : 1130-1136.
3. DE VILLE DE GOYET J., REDING R., SOKAL E., OTTE J.B. Related living donor for liver transplantation in children : impact and results. *Chirurgie*, 1997, **122** : 83-87.
4. OTTE JB., DE VILLE DE GOYET J., REDING R., VAN OBBERGH L., VEYCKEMENS F., CARLIER M., DE KOCK M., CLEMENT DE CLETY S., CLAPUYT PH., SOKAL E., LERUT J., DELBEKE V., DIERICK M., JANSSEN M., ROSATI R., LIBERT F. Pediatric liver transplantation : from the full-size liver graft to reduced, split and living related liver transplantation. *Ped. Surg. International*, 1998, **13** : 308-318.
5. REDING R., DE VILLE DE GOYET J., DELBEKE I., SOKAL E., JAMART J., JANSSEN M., OTTE J.B. Pediatric liver transplantation with cadaveric or living related donors : Comparative results in 90 elective recipients of primary grafts. *J. Pediatr.*, 1999, **134** : 280-286.
6. BISMUTH H., HOUSSIN D. Reduced-sized orthotopic liver graft in hepatic transplantation in children. *Surgery*, 1984, **95** : 367-370.
7. DE HEMPTINNE B., DE VILLE DE GOYET J., KESTENS P.J., OTTE J.B. Volume reduction of the liver graft before orthotopic transplantation. Report of a clinical experience in 11 cases. *Transplant. Proceed.*, 1987, **4** : 3317-3322.
8. DE VILLE DE GOYET J., OTTE J.B. Cut-Down and Split liver transplantation. Saunders, Ed Busuttil R.W. and Klintmalm G.B. Chap 48, 481-496 : 1995.
9. SOUBRANE O., HOUSSIN D., PITRE J., DOUSSET B., BERNARD O., CHAPUIS Y. Extrafascial hyper-reduction of the hepatic graft. *J. Am. Coll. Surg.*, 1994, **178** : 139-143.
10. OTTE J.B., DE VILLE DE GOYET J., ALBERTI D., BALLADUR P., DE HEMPTINNE B. The concept and technique of the split liver in clinical transplantation. *Surgery*, 1990, **107** : 605-612.
11. DE VILLE DE GOYET J. Split liver transplantation in Europe : 1988 to 1993. *Transplantation*, 1995, **59** : 1371-1376.
12. DE VILLE DE GOYET J., STRUYE DE SWIELANDE Y., REDING R., SOKAL E., OTTE J.B. Delayed primary closure of the abdominal wall after cadaveric and living related donor liver graft transplantation in children : a safe and useful technique. *Transpl. Int.*, 1998, **11** : 117-122.
13. EMOND J.C., HEFFRON T.G., WHITINGTON P.F., BROELSCH,C.E. Reconstruction of the hepatic vein in reduced size hepatic transplantation. *Surg. Gynecol. Obstet.*, 1993, **176** : 11-17.
14. DE VILLE DE GOYET J. Vascular Thrombosis after pediatric liver transplantation. Second International Congress on Pediatric Transplantation, Aug 1996, Paris (abstract).