Transpl Int (1996) 9 [Suppl 1]: S174–S177
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Extension of the indication for living related liver transplantation from children to adults based on resolution of graft size mismatch in relation to tissue oxygenation and metabolic load: a case report

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Abstract We extended the indication for living related partial liver transplantation from pediatric to adult cases. Our first case was a 49-year-old woman with primary biliary cirrhosis. Her sister's left lobe, weighing 280 g, was employed as a graft, and the graft weight/recipient's body weight ratio was calculated as 0.59 %. To decrease the metabolic load to the relatively small graft, the total bilirubin was decreased from a maximum value of 75.0 mg/dl to the most recent preoperative value of 36.2 mg/dl by plasma exchange. Intraoperative recovery of tissue oxygenation and its heterogeneity were satisfactory due to a relatively high blood supply. A postoperative decrease in bilirubin and increase in cholesterol esterification were facilitated, concomitant with regeneration of the graft, which weighed 280 g, to 860 cm^3 at 3 weeks. Linear regression analysis with respect to tissue oxygenation and metabolic capacity obtained in pediatric cases were applied to this adult case.

Key words Graft size mismatch · Living related liver transplantation in an adult · Tissue oxygenation · Metabolic capacity

Introduction

In partial liver transplantation with a living related donor, when the left lateral segment or left lobe is employed as the graft, the graft size and weight are anatomically limited within a narrow range. By contrast, the recipient body size is distributed over a wide range, namely, from infancy to adolescence, as shown in Fig. 1 [4, 6]. It has been reported that normal ratios of whole liver weight relative to body weight (BW) is 2 % in adults. Therefore, the ratio of graft weight to recipient body weight (G/R ratio) is a matter of serious concern in living related liver transplantation (LRLT). In 47 pediatric cases of LRLT, we have shown that the following are affected by the G/R ratio [5]: (1) the tissue oxygenation and synthetic and detoxication capability of the graft, in terms of oxygen saturation of hemoglobin in the liver sinusoid (SO_2) and coefficient of variation of SO_2 (CV) measured by near-infrared spectroscopy at multiple points, as indices of extracellular oxygenation and its heterogeneity, (2) arterial ketone body ratio (AKBR) as an index of intracellular oxygenation, (3) aspartate aminotransferase as an index of graft injury and, (4) bilirubin clearance, cholesterol esterification [3], and production of total ketone bodies as indices of the metabolic capability of the graft. Based on these results, we started a program of LRLT for adults.

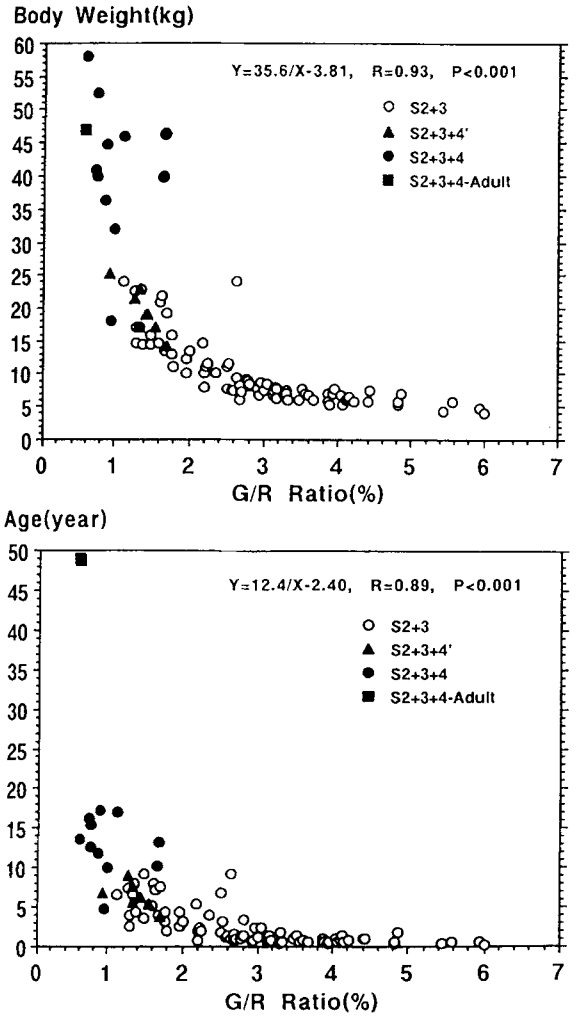

Fig. 1 Hyperbolic correlations among the ratio of graft weight to recipient body weight (G/R ratio), age, and body weight ratio in 100 pediatric cases and 1 adult case

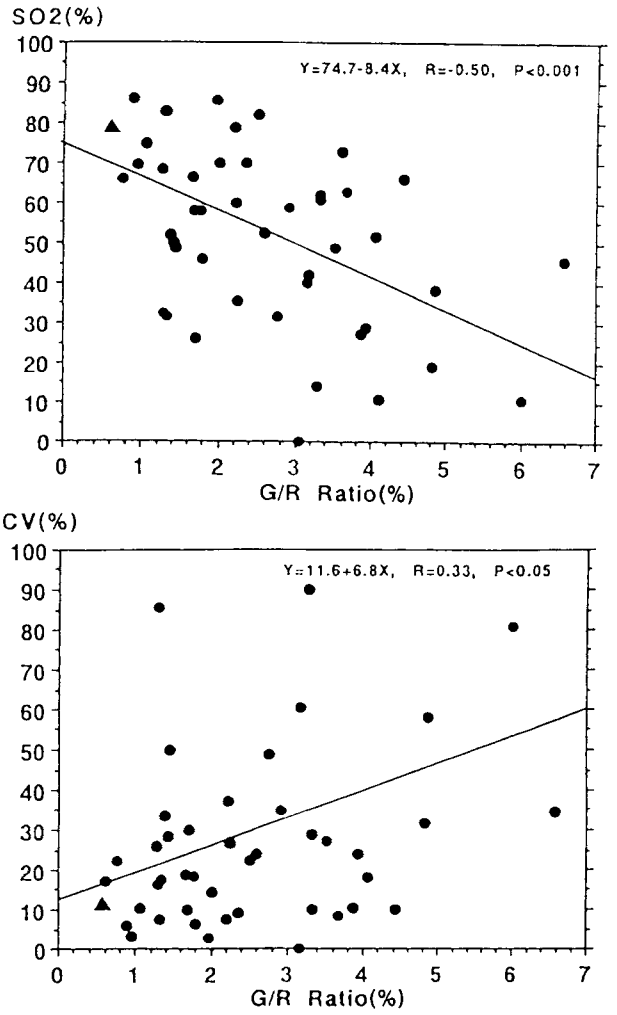

Fig. 2 Fitting of oxygen saturation of hemoglobin in the liver sinusoid (SO_2) and coefficient of variation of SO_2 (CV) after reflow of the portal vein in the adult case to the linear regression analysis obtained in 47 pediatric cases. *Triangle* indicates the adult case

A case report

Our first case was a 49-year-old woman who was suffering from primary biliary cirrhosis with a positive mitochondrial antibody. Ruptured esophageal varices were treated by sclerotherapy, but hepatic coma developed following a catheter infection. The Mayo Clinic risk score was 8.5 and her 1-year survival rate was expected to be less than 50 %. Her sister's left lobe, weighing 280 g, was employed as a graft, and the G/R ratio was calculated to be 0.59 %. To decrease the metabolic load to the relatively small graft, the total bilirubin was decreased from a maximum value of 75.0 mg/dl to a preoperative value of 36.2 mg/dl by plasma exchange on nine occasions. Intraoperative recoveries of SO_2 and its CV were satisfactory due to a relatively high blood supply. The total bilirubin decreased to 2.5 mg/dl and the ester ratio (ER: esterified cholesterol/total cholesterol) increased to 0.643, concomitant with sufficient regeneration of the graft, which weighed 280 g, to 860 cm^3 at 3 weeks.

Analysis of the tissue oxygenation and metabolic capacity of the graft in comparison with pediatric cases

Tissue oxygenation and its heterogeneity were assessed by the mean value of SO_2 and its CV at ten different points as measured by near-infrared tissue spectroscopy [2]. Synthetic and detoxication capacity of the graft were assessed by exponential recovery of the ER and exponential decay of total bilirubin (TBIL) as expressed as $\log_e$[ER(nPOD)/ER(nPOD)] and $\log_e$[TBIL(nPOD)/TBIL(nPOD)], respectively (POD: postoperative day).

In the present adult case, the SO_2 was 79.8 and 84.1 %, while the CV was 10.9 and 11.0 % after reflow of the portal vein and at the end of the operation, respectively. Figure 2 shows that the values of SO_2 and CV after reflow of the portal vein were nearly on the line obtained by the linear regression analysis of the 47 pediatric cases of our ealier study [5]. Log_e[TBIL(lPOD)/TBIL(preop)] and $\log_e$[TBIL(14POD)/TBIL(7POD)] were − 0.882 and − 0.257, respectively, while $\log_e$[ER(14POD)/ER(preop)] and $\log_e$[ER(28-

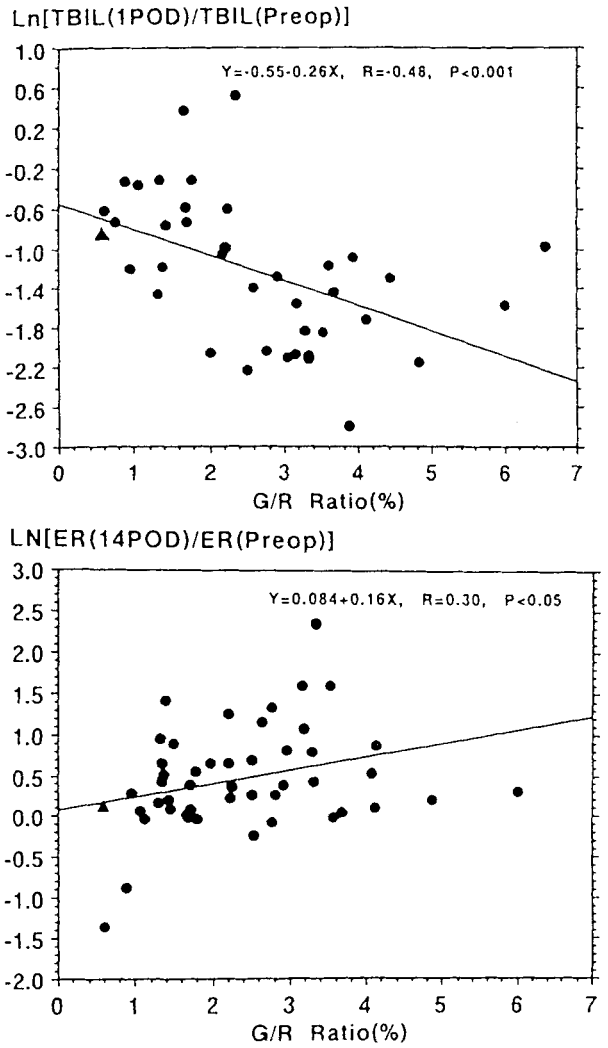

Fig. 3 Fitting of Log_e[TBIL(lPOD)/TBIL(preop)] and log_e[ER(14POD)/ER(preop)] in the adult case to the linear regression analysis obtained in 47 pediatric cases. *Triangle* indicates the adult case (*TBIL* total bilirubin, *POD* postoperative day, *ER* ester ratio)

POD)/ER(14POD)] were 0.137 and 0.257, respectively. Figure 3 shows that Log_e[TBIL(1POD)/TBIL(preop)] and log_e[ER(14-POD)/ER(preop)] were also nearly on the line obtained by the linear regression analysis of the 47 pediatric cases.

Discussion

The present study showed that, as compared with small infants with relatively large grafts, intraoperative recovery of tissue oxygenation and its heterogeneity in LRLT for an adult with a relatively small graft were satisfactory even after reflow of the portal vein because of sufficient blood supply. By contrast, both the synthetic capacity of the graft, as assessed by recovery of cholesterol esterification, and detoxication capacity, as assessed by increased bilirubin clearance, were retarded in the postoperative early phase, but were normalized in the late phase. Substantial increases in liver volume (60–200 %) have been reported to occur at 1 month after liver transplantation in cases where the graft liver is smaller than the ideal volume [1]. In our case of LRLT in a 49-year-old woman, the graft regenerated from the initial weight of 280 g to 860 cm^3 at 3 weeks after transplantation. Therefore, early and sufficient regeneration facilitated an increase in metabolic capability.

In the present adult case, the value of the G/R ratio was 0.59 %, which corresponded to 30 % (0.59 %/2.0 %) of the ideal graft volume, since the ideal ratio of liver weight to body weight is 2.0 %. It is known that the normal liver can tolerate right trisegmentectomy with resection of the caudate lobe, which reduces the liver volume by 80 %. Taking disadvantages of procurement, cold preservation, reperfusion, and subsequent immunologic events into consideration, a minimal value of 30 % in LRLT seems to be reasonable.

Since linear regression analysis with respect to tissue oxygenation and metabolic capacity obtained in pediatric cases were applied to this adult case, we concluded that LRLT, using relatively small grafts, can be performed successfully in adults when early regeneration is ensured. These results would suggest that the indication for LRLT can be extended to adult cases.

References

1. Kawasaki S, Makuuchi M, Ishizone S, Matsunami H, Terada M, Kawarazaki H (1992) Liver regeneration in recipients and donors after transplantation. Lancet 339: 580–581
2. Kitai T, Tanaka A, Tokuka A, Tanaka K, Yamaoka Y, Ozawa K, Hirao K (1993) Quantitative detection of hemoglobin saturation in the liver with near-infrared spectroscopy. Hepatology 18: 926–936
3. Sano K, Tanaka A, Uemoto S, Honda K, Tanaka K, Ozawa K (1993) Lipid metabolism after liver transplantation from a living related donor. Clin Sci 85: 83–88
4. Tanaka K, Uemoto S, Tokunaga Y, Fujita S, Sano K, Nishizawa T, Sawada H, Shirahase I, Kim HJ, Yamaoka Y, Ozawa K (1993) Surgical techniques and innovations in living related liver transplantation. Ann Surg 217: 82–91

5. Tanaka A, Tanaka K, Tokuka A, Kitai T, Shinohara H, Hatano E, Sato S, Inomoto T, Takada Y, Higashiyama H, Nakamura Y, Yamamoto Y, Egawa H, Uemoto S, Ikai I, Ozaki N, Inomata Y, Yamaoka Y (1996) Graft size-matching in living related partial liver transplantation in relation to tissue oxygenation and metabolic capacity. Transplant Int 9: 15–22

6. Yamaoka Y, Ozawa K, Tanaka A, Mori K, Morimoto T, Shimahara Y, Zaima M, Tanaka K, Kumada K (1991) New devices for harvesting a hepatic graft from a living donor. Transplantation 52: 157–160