Table 4: Patient survival following living donor liver transplantation

			Patient survival (%)				
	Number	%	1 year	5 years	10 years	15 years	20 years
Over all	2224		88.3	85.4	82.8	80.0	79.6
Donor age (p = NS; median 35.2 [range 17–70 years])							
<20 years	6	0.3	100.0	100.0	100.0	100.0	—
20 years ≤ <40 years	1646	74	88.9	86.4	83.9	81.7	81.2
40 years ≤ <60 years	543	24.4	86.5	82.8	79.7	74.7	74.7
≤60 years	29	1.3	82.1	78.6	78.6	—	—
Donor relation (p = NS)							
Father	952	42.9	88.2	85.8	82.7	80.2	79.4
Mother	1166	52.4	88.7	85.7	83.4	80.6	80.6
Gender mismatch (p = NS)							
Female→male	709	31.9	90.0	87.7	86.1	82.6	82.6
Female→female	517	23.2	87.0	83.2	79.9	78.3	78.3
Male→female	569	25.6	87.7	85.2	82.1	79.4	78.0
Male→male	429	19.3	87.8	84.8	81.8	79.1	79.1
Graft type (p = NS)							
Reduced left lateral segment	96	4.3	79.1	74.2	74.2	—	—
Left lateral segment	1549	69.6	89.8	87.6	85.1	83.4	82.9
Left lobe	500	22.5	84.8	80.2	76.9	70.5	70.5
Posterior segment	3	0.1	100.0	50.0	50.0	—	—
Right lobe	76	76	92.1	90.5	88.6	88.6	88.6
ABO compatibility (p < 0.01)							
Identical	1484	66.7	89.9	87.4	84.8	82.5	81.9
Compatible	446	20.1	87.4	83.7	81.2	79.1	79.1
Incompatible	294	13.2	81.3	78.3	75.0	68.5	—
Age at incompatible LT (p < 0.01)							
<2 years	185	62.9	84.8	83.4	81.3	81.3	—
2 years ≤ <10 years	36	13.3	76.7	72.3	66.7	48.6	—
10 years ≤ <18 years	73	24.8	72.2	63.7	59.2	49.3	—
Recipient sex (p = NS)							
Female	1278	57.5	89.0	86.6	84.3	81.2	80.6
Male	946	42.5	87.4	83.9	80.8	78.6	78.6
Recipient age (p < 0.01; median 4.0 years [range 13 days to 17.9 years])							
<6 months	106	4.8	81.1	72.9	70.5	70.5	—
6 months ≤ <1 year	613	27.6	89.2	87.6	86.1	85.3	85.3
1 year ≤ <5 years	789	35.5	90.2	88.7	85.8	85.1	84.1
5 years ≤ <10 years	320	14.4	90.0	85.3	81.3	76.1	76.1
10 years ≤ <18 years	396	17.8	83.5	79.1	76.5	68.4	68.4
Indication of liver transplantation (p < 0.01)							
Cholestatic diseases (p = NS)	1649	76.2	91.2	89.4	86.5	84.0	84.0
Biliary atresia (age at LDLT; p < 0.01)	1471	66.1	91.3	89.5	86.9	84.8	84.8
<6 months	44	3	90.9	87.7	87.7	87.7	—
6 months ≤ <1 year	503	34.2	92.2	91.4	89.6	84.8	84.8
1 year ≤ <5 years	535	36.4	93.1	91.6	88.8	87.9	87.9
5 years ≤ <10 years	177	8	92.6	91.2	87.7	83.4	—
10 years ≤ <18 years	212	14.4	83.5	79.0	75.4	68.4	—
Alagille syndrome	70	3.1	92.9	91.4	85.9	85.9	—
Byler disease	33	1.5	90.9	87.5	83.6	57.3	57.3
Primary sclerosing cholangitis	20	0.9	100.0	94.4	63.0	—	—
Metabolic disease (p < 0.001)	194	8.7	92.2	87.9	87.0	77.5	—
Wilson's disease	59	2.6	98.3	96.5	94.4	73.4	—
Urea cycle disorders	49	2.2	95.9	95.9	95.9	95.9	—
Organic acidemia	29	1.3	89.7	82.2	82.2	—	—
Glycogen storage diseases	15	0.7	92.9	69.3	—	—	—
Primary hyperoxaluria	9	0.4	55.6	55.6	55.6	55.6	—
Acute liver failure (age at LDLT; p < 0.01)	192	8.6	72.6	69.0	67.0	67.0	—
<1 year	83	43.3	61.4	57.3	54.2	54.2	—
≥1 year	109	56.7	81.3	78.1	76.6	76.6	—

(Continued)

Table 4: Continued

	Number	%	Patient survival (%) 1 year	5 years	10 years	15 years	20 years
Neoplastic diseases	66	3	84.8	72.7	69.9	69.9	69.9
Vascular diseases	32	1.4	93.8	85.7	85.7	85.7	85.7
Primary vs. re-transplantation ($p < 0.01$)							
Primary transplantation	2148	96.6	89.4	86.6	84.0	81.2	80.8
Re-transplantation	72	3.3	56.9	50.8	48.1	—	—
Re-re-transplantation	4	0.2	75.0	75.0	—	—	—
Center volume ($p = .NS$)							
High volume (≥50)	2033	91.4	88.1	85.2	82.5	79.7	79.3
Low volume (<50)	191	8.6	90.0	88.3	85.8	85.8	—
Transplantation era ($p < 0.01$)							
1989–1995	296	13.3	80.1	77.0	71.6	69.3	68.9
1996–2000	573	25.8	86.0	82.8	80.7	78.1	—
2001–2005	680	30.6	89.0	86.0	84.8	—	—
2006–2010	675	30.4	93.2	91.8	—	—	—

impact on posttransplantation mortality (16,17). Optimizing the pretransplantation status with nutritional management would be essential.

ABO-incompatible LDLT has been performed to mitigate the problems of the organ shortage in Japan. The graft survival rate of children younger than 2 years of age receiving ABO-incompatible grafts was similar to that of children receiving compatible grafts in the present series. Survival is gradually affected in association with age by specific complications related to antibody-mediated rejection such as focal hepatic necrosis caused by microcirculatory disturbances and the development of multiple non-anastomotic biliary strictures attributable to arteriole insufficiency (8). ABO-incompatible grafts were used in 13.2% of the recipients in the present series. Despite the application of preoperative plasma exchange, splenectomy and enhanced immunosuppression, the 15-year graft survival rate was less than 50% in children over 2 years of age. The recent introduction of rituximab in ABO-incompatible cases has improved graft survival in older recipients by inducing B cell desensitization (18,19). Recently, rituximab prophylaxis has become widely used, with improved outcomes. The percentage of patients receiving ABO-incompatible grafts has increased to 16.0%. Although providing long-term follow-up, including monitoring for late-onset neutropenia, is necessary in order to offer clear recommendations, children over 2 years of age can receive this alternative treatment modality (20). Moreover, operational immunosuppressant tolerance protocol, not limited to ABO-incompatible cases, was initiated in the early 1990s at Kyoto University, with a complete withdrawal rate of 38.1% in selected pediatric patients with monitoring gamma–delta T cells (21,22). Operational tolerance is one of the recent innovations in pediatric LDLTs.

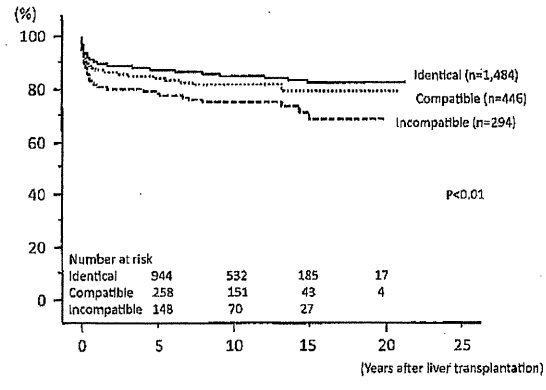

Figure 3: Patient survival following pediatric living donor liver transplantation according to ABO compatibility.

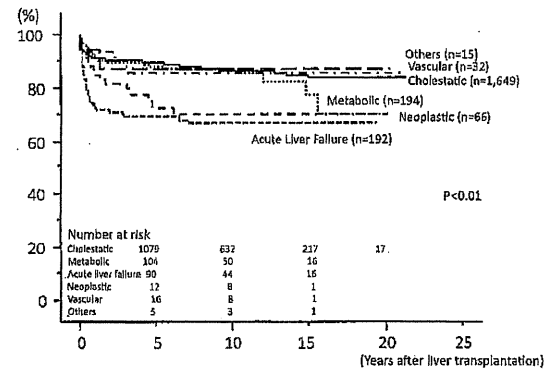

Figure 4: Recipient survival curves according to the original liver disease.

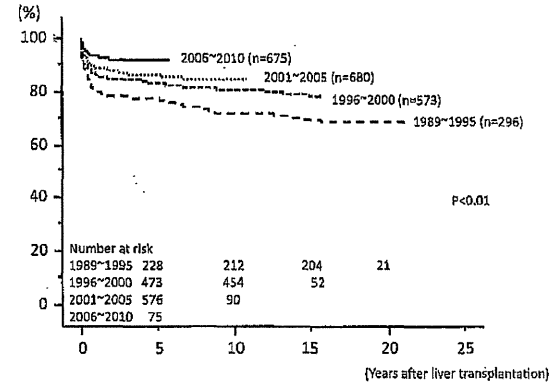

Figure 5: Recipient survival according to transplant era.

It has been reported that the cause of liver disease is a strong predictor of patient outcomes, and patients with cholestatic liver disease fair far better than those with other indications (9). Similar to the findings of the deceased LT series, patients with biliary atresia had a consistently better 20-year patient survival rate of 84.8% in the present series. Significantly worse patient survival, however, was observed in the patients with biliary atresia over 10 years of age, with a 20-year survival rate of 68.4%. The timing of LDLT in older patients with biliary atresia is crucial.

The present study confirmed that LDLT performed to treat metabolic disease can provide an acceptable survival rate of 77.5% over 15 years, although most donors in the present series were heterozygous for their respective recipients' disorders. While neither mortality nor morbidity related to heterozygosis were observed, an intensive investigation should be conducted in this donor population.

There are several reports of the use of deceased LT to treat acute liver failure in children, with reported overall patient survival rates of 60–75% (23,24). The overall survival rate of the patients with acute liver failure in the present study is comparable with 67.0% over 15 years. However, among acute liver failure patients less than 1 year of age, the patient survival rates were significantly lower in the short and long term (61.4% and 54.2% at 1 and 15 years, respectively) despite relatively appropriate availability of donors compared to deceased LT. The reasons for this difference are not well documented; however, long-lasting unknown hepatitis viral infections may cause accelerated immune responses, and the incidence of refractory acute or chronic rejection is higher in patients with acute liver failure of unknown etiology in infancy (25,26). Further immunological refinements and advances in perioperative intensive care are required for LT patients with infantile acute liver failure.

The patients undergoing LDLT for hepatic malignancy demonstrated a poorer 20-year survival rate of 69.9%. The potential advantage of LDLT is that it allows for optimal timing of LT, given the absence of delay between the completion of effective chemotherapy and planned LT (27).

Re-LT remains controversial in the setting of LDLT given the limitation of donors and the fact that previous reports have demonstrated poorer outcomes with re-LT than primary LT (28). Taking into consideration the recipient 10-year survival rate of 48.1% observed in the present study, determining clear indications and limitations for re-LDLT is necessary in order to avoid unequivocal morbidity and even mortality in potential living donor candidates.

Despite the increasing proportion of small children and ABO-incompatible cases, patient survival was significantly better among the patients undergoing LDLT more recently (5-year survival rate: 91.8%) due to perioperative patient management by pediatric specialists and surgical innovations and advances in immunosuppression, such as overcoming graft size matching and ABO incompatibility. In addition, the outcomes after LDLT observed in the present study were comparable to those of deceased LT (9,10,11). In our country, small deceased donors are less likely to become available, and LDLT is often the only treatment modality for patients with pediatric liver disease. Due to the unequivocal risks, efforts should be made to increase deceased LT in order to minimize the need for living donors.

Over the past two decades, medical and surgical innovations have established pediatric LDLT as the optimal therapy for patients suffering from acute or chronic liver disease. Our study, however, was limited by the restrictions, accuracy and consistency of the information contained within the JLTS database. We did not have access to preoperative patient conditions, recipient and donor laboratory data, immunosuppression protocols, morbidity, cause of death, growth or quality of life measures. As LDLT has been revealed to increase the donor pool and decrease pediatric waiting list mortality, conducting further investigations of the most important remaining causes of death in liver-transplanted children is essential. The JLTS started a new online detailed registration system in January 2013 that can be explored in detail. We hope that increased experience with and refinement of this procedure will lead to further improvements in outcomes among patients undergoing LT for pediatric liver diseases.

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Disclosure

The authors of this manuscript have no conflicts of interest to disclose as described by the *American Journal of Transplantation*.

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Appendix

The following constitute the pediatric JLTS research group enrolled in this study:

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ELSEVIER

Transgenic Pig Expressing the Red Fluorescent Protein Kusabira-Orange as a Novel Tool for Preclinical Studies on Hepatocyte Transplantation

T. Shigeta, H.-C. Hsu, S. Enosawa, N. Matsuno, M. Kasahara, H. Matsunari, K. Umeyama, M. Watanabe, and H. Nagashima

ABSTRACT

Introduction. Research on hepatocyte transplantation as an alternative or supplementary treatment for liver transplantation is progressing. However, to advance to clinical trials, confidence in the technique must be established and its safety must be validated by conducting experiments using animals of comparable sizes to humans, such as pigs. We used transgenic pigs expressing red fluorescence protein for investigating the distribution and survival of transplanted cells.

Materials and Methods. Donor hepatocytes were isolated from transgenic Kusabira-Orange (KO)-expressing pigs (age, 41 days; weight, 10 kg) created by in vitro fertilization using sperm from a transgenic-cloned KO pig by Matsunari et al. and ova from a domestic pig. The hepatocyte transplant recipients were the nontransgenic, KO-negative littermates. In these recipient pigs, double lumen cannulae were inserted into the supramesenteric veins to access the hepatic portal region. KO-positive donor hepatocytes from the transgenic male pig were isolated using collagenase perfusion. Hepatocytes (1×10^9 cells) were transplanted through the cannula. For estimating allogeneic immunogenicity, full-thickness skin (3×3 cm) from the same donor was grafted orthotopically on the neck region of the recipients. Immunosuppressive treatment was not implemented. The recipient pigs were humanely killed at 7 and 39 days after transplantation, and the organs were harvested, including the lungs, heart, liver, pancreas, and kidneys.

Results. Strong red fluorescence was detected in both the parenchymal and nonparenchymal hepatocytes of the transgenic male donor pig by fluorescent microscopy. Transplanted cells were detected in the liver and lung of the recipient pigs at 7 days after perfusion. Hepatocytes remained in the liver and lung of recipients on day 39, with lower numbers than that on day 7.

Conclusion. Transgenic pigs expressing the fluorescent protein KO serve as a useful model of cell transplantation in preclinical studies.

HEPATOCYTE transplantation (HCT) is considered to be an alternative or supplementary treatment for liver transplantation (LT) in urea cycle disorders (UCD), including ornithine transcarbamylase deficiency and carbamyl phosphate synthetase 1 deficiency, in addition to acute liver failure (ALF).[1,2] HCT has many advantages compared with LT. For instance, it is less invasive, feasible as a partial or temporal liver support for metabolic disease or ALF, could be supplied from a marginal graft, and could be ready-to-use on demand.[1–4] However, HCT research is at the pioneering stage, despite increasing numbers of case reports for clinical HCT.[1,5–10] Moreover, because UCD is

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most common in neonatal patients, size mismatches of liver grafts represent a major problem at the time of LT. Therefore, these patients must wait until reaching about 7 kg.[10–12] During the waiting time for LT, patients are at risk of hyperammonemia, developing severe neurological impairments, or lethal coma.[2,12,13] Thus, HCT can be performed to prevent such problems in the treatment of UCD and ALF as a bridge to LT. To advance to clinical trials, confidence in the technique must be established and its safety must be validated by conducting experiments using animals of comparable sizes to humans, such as pigs. This study shows the use of transgenic pigs expressing red fluorescence to investigate the distribution and survival of transplanted cells.

MATERIALS AND METHODS

Donor hepatocytes were isolated from transgenic Kusabira-Orange (KO)-expressing pigs (age, 41 days; weight, 10 kg) created by in vitro fertilization using the sperm from a transgenic-cloned KO male pig by Matsunari et al. and ova of a domestic pig.[14]

KO-positive donor hepatocytes were isolated from the male transgenic pig by collagenase (032-10534 Wako Pure Chemicals, Osaka, Japan) perfusion; furthermore, the parenchymal hepatocytes were obtained through low-speed centrifugation (50 *g*, 1 minute, 3 times).[15,16]

Two offspring (recipients) that were nontransgenic, KO-negative littermates, were used in this study. Under isoflurane anesthesia, minimal abdominal midline incisions were made in both of the recipient pigs. Then, double lumen cannulae (18 gauge; Medicut LCV-UK; Tyco Healthcare, NJ, United States) were inserted into the supramesenteric veins of both the pigs, to access the portal vein trunk. The proximal end was used for portal pressure assessment, whereas the distal end was used for HCT. Hepatocytes (1×10^9 suspended in 100 mL saline containing 5 U/mL heparin) were transplanted once though the cannulae. To estimate allogeneic immunogenicity, full-thickness skin (3×3 cm) from the same male donor was grafted orthotopically onto the neck region of the nontransgenic recipient pigs. Immunosuppressive treatment was not implemented. The 2 recipient pigs were humanely killed at 7 (recipient 1) and 39 (recipient 2) days after transplantation, and the organs were harvested for examination, including the lungs, heart, liver, pancreas, and kidneys. Isolated organ specimens were sliced into 5- to 10-mm pieces, and observed using fluorescent microscopy.

RESULTS

Strong red fluorescence was detected in both the parenchymal and nonparenchymal hepatocytes of the male transgenic donor pig using fluorescent microscopy (Fig 1). Multiple transplanted cells were detected in the liver and lung of recipient 1, whereas the skin graft was rejected within 7 days. Hepatocytes remained in the lung and liver of recipient 2 for 39 days, with a lower number than that in recipient 1. While the skin graft was acutely rejected, the hepatocytes remained for up to 39 days. KO-positive hepatocytes were not detected in the heart, pancreas, or kidney, and no obvious ischemic change was observed on the liver surface of either recipient.

DISCUSSION

To our knowledge, this report shows the first record of using KO-transgenic hepatocytes for HCT experiments. Matsunari et al produced transgenic-cloned pigs carrying a humanized *KO* gene, which is a newly developed red fluorescent protein.[14] KO was cloned from the mushroom coral *Fungia concinna*, which yields orange-red fluorescence in its dimeric form and has 558 and 583 nm excitation and emission maxima, respectively.[17] In addition to KO transgenic pigs, transgenic pigs expressing enhanced green fluorescent protein (EGFP) were studied.[18] As a major feature, KO showed minor background autofluorescence in the liver and lung of humanized KO transgenic pigs compared with EGFP transgenic animals, in which the organs are known to exhibit autofluorescence.[19,20] Furthermore, the clear red fluorescence of the humanized KO protein is maintained even in paraffin-embedded tissue sections.[14]

In our study, lung distribution was identified, although there was no obvious presentation of pulmonary embolization. Interestingly, only a few studies have documented the possibility of pulmonary embolization after HCT.[1,8,21] Muraca et al showed that hepatocytes remained in the lung sinusoids for up to 48 hours after infusion in all pigs;

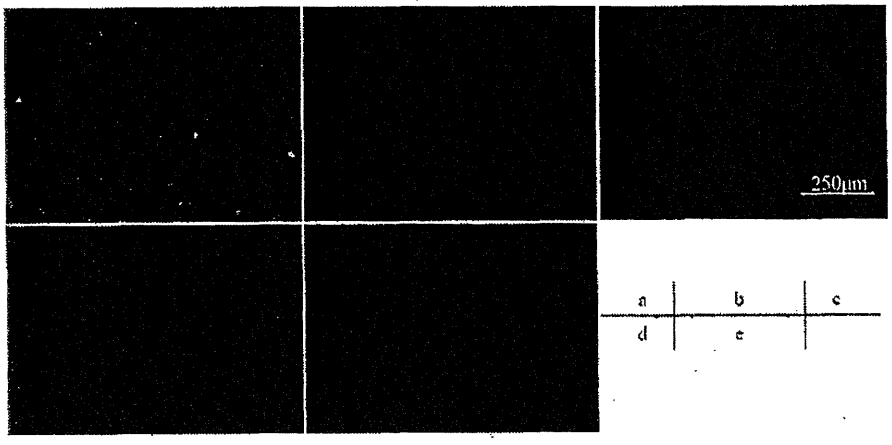

Fig 1. **(a)** Fluorescent microscopy images showing strong red fluorescence in both parenchymal and nonparenchymal hepatocytes of the transgenic donor pig. Transplanted KO-expressing transgenic hepatocytes were detected 1 week after hepatocyte transplantation **(b)** in the liver and **(c)** lung. Transplanted KO-expressing transgenic hepatocytes were detected about 1 month after hepatocyte transplantation **(d)** in the liver and **(e)** lung.

furthermore, a minor basal pulmonary infarction was identified in one of the pigs.[21] In addition, they showed that the number of infused cells was directly correlated with increased portal pressure, but not increased pulmonary artery pressure. They suggested that local vasoconstriction might contribute to the observed increase in pulmonary artery pressure after HCT. Bilir et al reported that intraportal HCT in patients with ALF was followed by hypoxia and pulmonary infiltrates in chest cardiographs, both of which improved after 24 hours.[1] In clinical HCT, hepatocytes were infused several times; hence, portal vein complication represents a serious complication.[5,8,21] In addition, there is a risk of pulmonary embolism due to the repeated infusion of hepatocytes, despite only a small number of hepatocytes passing through the liver. There was no evidence of the intrapulmonary shunt causing a problem to the experimental pigs. However, the safety of intraportal HCT requires further improvement, along with further investigations about the risk of pulmonary embolization. KO hepatocytes remained in the liver and lung for about 1 month. However, our study had a limitation in that we could not identify whether these hepatocytes were functional. Therefore, experiments using animal disease models should be considered in future studies.

Analysis of antigenicity of the donor-recipient combinations in the current study indicated that KO was xenogeneic, whereas somatic cells were allogeneic. Because KO is an intracellular protein, xenogeneic antigenicity might not accelerate normal allogeneic rejection. Immunosuppressive treatment might induce extended survival. One major problem in the clinical application of HCT is the low survival rate of donor cells. It has been hypothesized that the quick disappearance of HCT cells is due to a nonspecific inflammatory response or instant blood-mediated inflammatory reaction (IBMIR); however, the precise mechanisms require clarification.[22] The transgenic pigs used here might serve as a conclusive research tool to overcome the deficit in information, as well as toward improving the cell transplantation procedure. In addition, identical clones of nontransgenic and transgenic littermates obtained by the nuclear transfer methodology might help create a more simple research model for IBMIR research focus.[23] In conclusion, the transgenic pig expressing fluorescent protein KO provides a useful model in cell transplantation preclinical studies.

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ORIGINAL ARTICLE

Impact of the current organ allocation system for deceased donor liver transplantation on the outcomes of pediatric recipients: a single center experience in Japan

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Abstract
Purpose The aim of this study was to analyze the outcomes of children added to the waiting list for deceased donor liver transplantation (DDLT) and the results of DDLT in a single Japanese center.
Methods Forty-seven children were listed on the organ allocation system for DDLT. The priority points related to the medical status of each patient were evaluated and stratified into four categories; 10, 8, 6, and 3 points. The clinical data were collected from the medical records, and the outcomes were analyzed.
Results There were 10 priority points in 25 patients, 6 points in 13 and 3 points in 9. Ten recipients (21.3 %); 7 patients with 10 points and 3 patients with 6 points, underwent DDLT. Seven out of the 10 recipients received split/reduced liver grafts. The surgical complications consisted of biliary stricture, hepatic venous outflow obstruction, intraabdominal abscess and intraabdominal bleeding. Two recipients, who were critically-ill before DDLT, died due to sepsis. The one-year graft survival rate was 70.0 %, with a median follow-up period of 6.4 months.
Conclusion The initial experience with pediatric DDLT in our series was satisfactory. Split LT of deceased donor organs may have the potential to resolve the serious organ shortage in Japan.

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Keywords Deceased donor liver transplantation · Living donor liver transplantation · Organ allocation system · Split liver transplantation

Introduction

In Japan, the number of deceased donor liver transplantation (DDLT) has gradually increased since the enforcement of a new law on organ transplantation in 2010. In contrast, living donor liver transplantation (LDLT) has been an established therapeutic option for children with End-Stage Liver Disease (ESLD), and LDLT has been adopted as an optional life-saving procedure for children in urgent need of liver transplantation (LT) [1]. Although the number of deceased organs does not alleviate the shortage of organs in our country, a positive impact produced by the increasing number of deceased donor organs may be expected in the pediatric population requiring LT. We herein report the outcomes of the pediatric recipients enrolled on the waiting list for DDLT and the results of DDLT in our series.

Patients and methods

Since July 2010, 47 children with ESLD, consisting of 15 males and 32 females, were included on the waiting list for the organ allocation system for DDLT in Japan. The median age of the patients enrolled on the waiting list was 2.8 years, ranging from 11 days to 17 years. The original diseases consisted of acute liver failure (ALF) in 20 cases, cholestatic liver diseases in 11, congenital hepatic fibrosis (CHF) in 6, graft failure after LDLT in 4, autoimmune liver diseases in 3, and metabolic liver diseases in 3, respectively. The clinical data were collected from the medical

records, and the patient outcomes were retrospectively analyzed under the permission of the institutional review board of the National Center for Child Health and Development.

The organ allocation system for DDLT in Japan

Livers will be offered to the DDLT candidates having the highest number of points receiving the highest priority. The priority points are calculated by considering the medical status and ABO blood type similarity of the patients. The points related to the medical status are stratified into four categories: 10 points, patients who are expected to survive 1 month or less without LT; 8 points, patients who are expected to die within 3 months; 6 points, those expected to die within 6 months and 3 points, those expected to die within 12 months. The medical status of each patient is evaluated according to the criteria for determining the original disease. For example, the patients of ALF with hepatic encephalopathy are considered to have 10 points. The patients with cholestatic diseases, such as biliary atresia, may be assigned 6 points when the episodes of cholangitis and/or gastrointestinal bleeding are repeated and refractory to medical treatment. The Child-Pugh classification is also used for the evaluation of the patients with cirrhosis. The patients with Child-Pugh class C have 6 points, while those with Child-Pugh class B are assigned 3 points.

Management during the period on the waiting list

Each patient on the waiting list for DDLT continued to receive medical treatment until the offer of a deceased donor organ. If there was a living donor candidate for LDLT, a thorough medical evaluation was performed to determine the suitability of the donor. Donors were selected on the basis of the results of the medical evaluations, including liver function tests, ABO blood group typing and graft/recipient size matching, as described previously [2]. In the selected patients has a chance of undergoing LDLT as a back-up therapeutic option, LDLT was performed after the family's consent to proceed with LDLT was obtained, because of the shortage of deceased donor organs in our country.

Procedure for donor procurement and DDLT

During the donor operation, the whole liver was retrieved using University of Wisconsin solution for organ preservation in the standard fashion. The reduction or splitting of a whole liver was performed in an ex vivo manner as a graft for smaller patients, if required. The recipient operation was performed in a piggy-back fashion without a veno–veno bypass. If the inferior vena cava (IVC) was attached to the graft, the side-to-side cavo-caval anastomosis was performed by making a wide orifice on the IVC of the recipient and the graft sides. Otherwise, an end-to-side hepatic venous anastomosis was performed in the same manner as that used for LDLT. The reconstructions of the portal vein and the hepatic artery were performed in an end-to-end fashion. A hepatico-jejunostomy was performed by inserting a stent tube, except in one case with duct-to-duct biliary anastomosis (Case 10).

Postoperative management after DDLT

The basic immunosuppressive regimen consisted of tacrolimus and low-dose steroids. Patients were weaned off steroids by 6 months after DDLT, when their liver function was stable. A liver biopsy was performed when indicated. Acute cellular rejection (ACR) was treated with a high dose of methylpredonisolone, which was used as steroid pulse therapy if the liver function did not improve.

Results

Clinical outcomes of the patients on the waiting list for DDLT

The priority points related to the medical status consisted of 10 points in 25 patients, 6 points in 13 patients, and 3 points in 9 patients (Table 1). The majority of the patients with 10 points were suffering from ALF. Consequently, 7 patients were considered to be candidates for DDLT, and 13 patients underwent LDLT without having a chance to obtain a graft from a deceased donor. Three patients with ALF did not need LT because of the improvement of their conditions by medical treatment. One patient with graft failure after LDLT died without undergoing LT. In terms of the patients with 6 points, three patients underwent DDLT and nine patients underwent LDLT. One patient with Alagille syndrome was once enrolled on the waiting list for DDLT; however, his concomitant cardiopulmonary disease became worse and he subsequently died. Among the patients with 3 points, six patients underwent LDLT and three patients are still on the waiting list.

Clinical outcomes of the patients undergoing DDLT

Ten recipients, consisting of three males and seven females, underwent DDLT (Table 2). The median age at DDLT was 10.5 months, ranging from 18 days to 17 years. The interval from the enrollment on the waiting list to DDLT ranged from 2 days to 1.5 years. All of the recipients with 10 points underwent DDLT within an interval of

Table 1 Clinical outcomes of the patients on the waiting list for DDLT

Priority points	10 points (n = 25, 53.2 %)	6 points (n = 13, 27.7 %)	3 points (n = 9, 19.1 %)
Age enrolled in the waiting list, median (range)	10.0 months (11 days–17 years)	3.0 years (5 months–16 years)	4.1 years (4 months–14 years)
Original disease			
Acute liver failure	20 (80.0 %)	–	–
Cholestatic liver diseases	–	6 (46.2 %)	5 (55.6 %)
Congenital hepatic fibrosis	–	4 (30.8 %)	2 (22.2 %)
Graft failure after LDLT	4 (16.0 %)	–	–
Autoimmune liver diseases	–	1 (7.7 %)	2 (22.2 %)
Metabolic liver diseases	1 (4.0 %)	2 (15.4 %)	–
Outcomes			
DDLT	7 (28.0 %)	3 (23.1 %)	–
LDLT	13 (52.0 %)	9 (69.2 %)	6 (66.7 %)
Patient died	1 (4.0 %)	–	–
Improved	3 (12.0 %)	–	–
Too sick to LT	–	1 (7.7 %)	–
Withdraw	1 (4.0 %)	–	–
Still waiting	–	–	3 (33.3 %)

DDLT deceased donor liver transplantation, *LDLT* living donor liver transplantation, *LT* liver transplantation

10 days, while the recipients with 6 points underwent the DDLT 45, 221 and 571 days after their enrollment on the waiting list. The age of the deceased donors was <6 years in one case, 6–18 years in one case, 18–49 years in five cases and ≥50 years in three cases. Three recipients received whole liver grafts and seven recipients received split/reduced liver grafts, consisting of right lobe in one case, left lobe in one case, left lateral segments (LLS) in three cases and reduced LLS in two cases. The graft weight to recipient body weight ratio ranged from 1.39 to 5.75 (mean ± SD; 3.36 ± 1.44). The mean cold ischemic time was 480.3 min, ranging from 296 to 839 min. Surgical complications after DDLT occurred in four cases. One patient (Case 3) suffered from hepatic venous outflow obstruction on postoperative day (POD) 26. Despite successful venoplasty with stent insertion, she subsequently received another graft from a living donor due to progressive graft failure. The macroscopic findings of the explanted graft did not show an anastomotic stricture of the hepatic vein, although the pathological findings revealed necrosis of the first graft due to sinusoidal obstruction syndrome [3]. One patient (Case 10) using duct-to-duct biliary anastomosis suffered from biliary stricture, which was successfully revised to hepatico-jejunostomy on POD 41. Medical complications after DDLT occurred in four cases, including convulsion related to tacrolimus neurotoxicity in two cases, intracranial hemorrhage in one case, and acute renal failure in one case. The case suffering from acute renal failure (Case 10) required hemodialysis during the immediate postoperative period, and basiliximab was simultaneously introduced to lower the blood concentration of tacrolimus. Three recipients experienced episodes of ACR, which were successfully managed by steroid pulse therapy. Two recipients who were critically-ill before DDLT; one with high-output syndrome with multiple hepatic hemangiomas (Case 2) and one with graft failure after LDLT with a Model for End-Stage Liver Disease (MELD) score of 50 (Case 9), died due to sepsis. The one-year graft survival was 70.0 %, with a median follow-up period of 6.4 months.

Discussion

Recent advances have proven that LDLT is a viable option for obtaining grafts in a timely fashion. Especially for children with ALF who are considered to be a high-urgency situation that requires LT, LDLT has been adopted as an optional life-saving procedure, although various ethical dilemmas and possible constraints resulting from the short duration of time for the psychological evaluation of the donor and family still remain [4]. Our present results revealed that the majority of the patients with 10 points, the highest priority for liver allocation, received grafts from deceased or living donors, and only one patient with graft failure after LDLT died without having a chance to obtain a graft from a deceased donor. The number of deceased donors has been increasing in our country; however, it still remains insufficient, and pediatric LT still relies on living donors.

Table 2 Clinical outcomes of the patients undergoing DDLT

Case no.	Age at DDLT /gender	Original disease	Priority points	Interval to DDLT (days)	Age of donors (years)	Type of graft	CIT (min)	Complications	Outcomes	Follow-up period
1	0 month/M	ALF	10	8	18–49	Reduced LLS (split LT)	378	–	Alive	6.5 months
2	2 months/F	ALF	10	6	18–49	Reduced LLS (split LT)	600	Intraabdominal bleeding, Intracranial hemorrhage	Died	10 days
3	8 months/F	ALF	10	2	≥50	LLS (reduced LT)	414	Hepatic venous outflow obstruction	Re LDLT	32 days
4	9 months/F	Graft failure	10	7	<6	Whole	468	–	Alive	9.6 months
5	10 months/F	Graft failure	10	9	18–49	LLS (split LT)	501	–	Alive	6.3 months
6	1 year/F	Cholestatic disease	6	45	18–49	LLS (split LT)	296	–	Alive	2.2 years
7	9 years/F	ALF	10	2	18–49	LL (split LT)	334	Convulsion	Alive	2.6 years
8	15 years/F	PSC	6	221	6–18	RL (split LT)	483	–	Alive	1.6 years
9	17 years/M	Graft failure	10	4	≥50	Whole	490	Convulsion, Intraabdominal abscess	Died	47 days
10	17 years/M	OTCD	6	571	≥50	Whole	839	Acute renal failure, Biliary stricture	Alive	4.9 months

ALF acute liver failure, *CIT* cold ischemic time, *DDLT* deceased donor liver transplantation, *LDLT* living donor liver transplantation, *LL* left lobe, *LLS* left lateral segments, *LT* liver transplantation, *OTCD* ornithine transcarbamylase deficiency, *PSC* primary sclerosing cholangitis, *RL* right lobe

An ideal organ allocation system can offer a liver graft to a candidate for DDLT fairly and impartially. For that purpose, the priority of liver allocation should be appropriately evaluated by considering the medical status and waiting time of each candidate. Certain scoring systems, like the MELD score for adult patients and the Pediatric End-Stage Liver Disease (PELD) score for the pediatric patients in the United States, has been applied and have been demonstrated to be useful to assign candidates for DDLT [5]. From the standpoints of the pediatric population requiring LT, various original liver diseases may be indications for LT. For example, congenital metabolic diseases, such as urea cycle disorder and hyperoaluria, are illnesses peculiar to children, and the patients do not usually show synthetic dysfunction of the liver. The liver allocation policy in the United States deals with this clinical condition as an exceptional disease to give extra priority for liver allocation [6]. CHF is also a chronic liver disease with preserved liver synthetic function. Our patients with CHF were evaluated to have a lower priority for liver allocation. However, the disease is often associated with autosomal recessive polycystic kidney disease, which may lead to concomitant renal insufficiency, and the majority of the patients with congenital hepatic fibrosis may require combined or sequential liver and kidney transplantation. The Japanese allocation system for liver and kidney organs accords a liver recipient priority for receiving a kidney from the same deceased donor. Under these circumstances and due to the shortage of deceased donors, it is often unavoidable to use a living donor for at least one organ [7]. Although it is difficult to evaluate the priority of liver allocation for pediatric and adult candidates for DDLT in an equitable manner, our allocation system related to each original liver disease peculiar to children must be revised to give higher priority than the current system when more deceased donors become available.

Split LT has been perceived as an important strategy to increase the supply of liver grafts by creating two transplants from each allograft. This procedure may carry the utmost importance because it can increase the available grafts for the pediatric recipients [8]. According to the 2011 OPTN/SRTR annual report, split LT was performed for 18.8 % of pediatric DDLT between 2009 and 2011 [9]. The introduction of this procedure has dramatically decreased the need for living donation at many pediatric transplant centers in the United States [10]. The previous reports showed that the long-term graft survival rates in children for segmental grafts from deceased donors were comparable with those for whole organ LT [11]. Proper donor and recipient selection for split LT is crucial for optimal organ allocation and for the best use of a scarce and precious resource. According to the previous reports from major transplant centers, the ideal split liver donor should be between 14 and 50 years of age, with good liver function, a serum sodium level <160 mmol/L, a short intensive care unit (ICU) stay, stable hemodynamics, with a grossly normal liver, and with a cold ischemia time less than 10 h [12]. In terms of the recipient selection for split LT, the use of split grafts in critically-ill recipients, such as those with MELD score > 30, and retransplant patients diminished the patient survival [13]. In our series, all six patients who received a split graft received the graft from a relatively younger donor, who ranged from 16 to 45 years, and who had a mean cold ischemia time of 7.2 h. On the other hand, the recipients who received a split graft included three patients with ALF and one case of graft failure after LDLT as the underlying liver disease. The outcome of our series of split LT is satisfactory, even when the relatively critically-ill recipients are included.

In conclusion, although pediatric LT in Japan still has to rely on living donors, the increasing number of deceased donor organs can reduce the burden of living donors in the future. The initial experience with pediatric DDLT in our series was satisfactory. Split LT of deceased donor organs may help to resolve the serious organ shortage in our country.

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Conflict of interest None.

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症例報告

自施設における小児脳死分割肝移植6例の成績

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キーワード　小児，肝移植，分割肝移植，脳死肝移植

I. 内容要旨

目的：2010年7月に脳死法案が改正され，脳死臓器移植は増加傾向にある．しかし脳死肝移植提供は全ての末期肝疾患患者の需要を満たすには至っていない．分割肝移植は肝臓を二つに分割し，二名のレシピエントに移植を行う術式である．自施設での分割肝移植6例の成績を検討し，文献的考察を含めて報告する．

対象と方法：国立成育医療センターにおいて2010年10月から2012年10月までに肝移植を行った217例中，分割肝移植6例について移植適応，手術成績について検討した．

結果：対象疾患は劇症肝炎3例，再移植1例，原発性硬化性胆管炎1例，胆道閉鎖症1例であった．レシピエント年齢は生後17日から15歳で，体重は2.4kgから55kgであった．分割移植片は縮小外側領域1例，外側領域3例，左葉1例，右葉1例であった．劇症肝炎の1例をVenoocclusive desease による移植肝不全で生体再肝移植を要したが，6例全例生存中である．

結論：経過観察期間は短いが，分割肝移植は適応を選べば安全な医療であると考えられた．

II. はじめに

2010年7月に「臓器の移植に関する法律（臓器移植法）」が改正され，15歳未満の臓器提供およびに家族同意による臓器提供が可能となった[1]．これにより脳死下臓器提供は飛躍的に増加し，改正臓器移植法施行後から2012年10月現在までのほぼ2年間で100例の脳死臓器提供が実施された[2]．一方，健常人をドナーとする生体肝移植は年間450例程度実施されており，依然生体肝移植が本邦における肝移植の主流であることに変わりはない[3]．欧米では慢性的なドナー不足を解消するため，一つの肝臓を二つに分割し二名のレシピエントに移植する分割肝移植が行われてきた（図1）[4)-6)]．分割肝移植は慢性的な小児脳死ドナー不足を解消する手段として1990年に開始され，小児脳死肝移植患者の待機中死亡率を低下させ得る有効な治療手段であると報告されている[7]．本邦でも2000年に京都大学と信州大学間で分割肝移植が初めて行われ，現在まで13例の分割肝移植が実施されている[2]．当施設は2005年11月に肝移植プログラムを開始し，現在まで220例の肝移植を実施してきた[8]．また2010年10月に18歳未満の脳死移植実施施設認定を受け，6例の分割肝移植を含む9例の脳死肝移植を実施した．当院における分割肝移植の成績を検討し，分割肝移植の現状について文献的考察を含めて報告する．

III. 対象と方法

2005年11月から2012年10月に217例の肝移植（含む5例肝腎移植）を実施した．2010年10月より18歳未満の脳死肝移植実施施設認定を受け，同時に小児末期肝疾患患者に対する脳死登録を開始した．脳死肝移植適応は国立成育医療研究センター内の適応評価委員会（国立成育医療研究センター倫理申請課題404）

INITIAL EXPERIENCE OF SPLIT LIVER TRANSPLANTATION IN NATIONAL CENTER FOR CHILD HEALTH AND DEVELOPMENT, JAPAN

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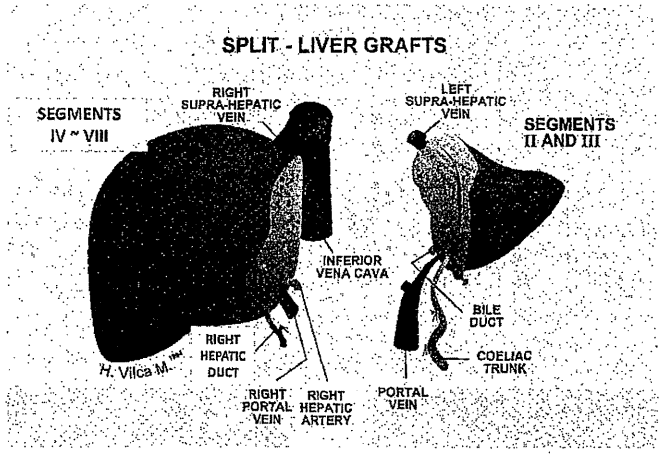

図1　分割肝移植（外側区域・右葉）シェーマ

で厳正に審査されたのち，関係学会代表で構成される脳死肝移植適応評価委員会（市田隆文委員長）で適応および医学的緊急度が速やかに判断される．脳死肝移植適応評価委員会の審査後，日本臓器移植ネットワークに脳死肝移植患者として登録される．

医学的緊急度は予測余命が1カ月以内；10点，1～3カ月以内；8点，3～6カ月以内；6点，6～1年以内；3点，1年を超えるもの1点に分類されている．血液型は一致および適合の待機者（レシピエント）を候補者とされている．しかし小児脳死肝移植レシピエントでは，選択時2歳未満の場合はその移植成績に有意差がないため，医学的緊急度10点の場合に限り血液型に関わらず1.5点が加算される．また脳死臓器提供者（ドナー）が18歳未満の場合には，選択時18歳未満の移植希望者に限り1点が加算されるという小児レシピエント優位な基準が設定されている[2]．

当院では肝移植適応患者の説明時に，脳死肝移植・生体肝移植ともに治療方法として提示し，家族の強い希望がある場合・生体ドナーが不在の場合に脳死肝移植登録を行う方針としている．2010年10月の脳死登録開始から2012年10月までに50例の脳死肝移植登録（含む1例脳死肝腎移植登録）を行い，そのうち9例（18%）に脳死肝移植を実施した．このうち分割肝移植は6例で，全肝移植2例，減量肝移植が1例であった．同時期に実施した生体肝移植は72例であった．分割肝移植6例で脳死登録を行った理由は，5例で医学的理由により生体肝移植ドナーが不適格，1例は家族の希望（生体肝移植準備中）であった．

臓器摘出は最小限の肝脱転を行い大動脈・下大静脈に送血管・脱血管を挿入し，University of Wisconsin液で移植臓器を還流後に肝単独摘出を行った[9]．臓器提供施設の手術室Back tableで移植肝の分割を，ペアン破砕法で行った．自施設に臓器搬送後，門脈から再度保存液で灌流し肝断端からの保存液流出を縫合閉鎖し，分割肝断端にFibrin glueを使用した．

IV. 結　果

レシピエント年齢は生後17日から15歳で，体重は2.4kgから55kgであった（表1）．原疾患は劇症肝炎3例，生体肝移植後肝不全1例，原発性硬化性胆管炎1例，胆道閉鎖症1例であった．医学的緊急度は最も緊急を要する10点が4例，6点が2例で，臓器移植ネットワークの登録から脳死肝移植実施までの期間は2日から218日であった．血液型適合性は一致および適合が4例，2歳未満の2例で血液型不適合移植を実施した．当該施設における分割肝移植の移植片は，縮小外側領域1例，外側領域3例，左葉1例，右葉1例であった．脳死肝臓摘出から移植肝臓の再灌流までの時間（冷阻血時間）は4時間56分から8時間21分であった．臓器摘出病院での分割操作時間は，30分から1時間20分であった．生後17日の新生児劇症肝炎症例（症例1）において，外側領域をさらに縮小する手技を，臓器搬送後に自施設のBack tableで行った[10]．

脳死移植手術手技はレシピエント下大静脈を温存したPiggy bag methodで行った．下大静脈付き移植片

表1　国立成育医療センターにおける脳死分割肝移植症例

症例	年齢	体重(kg)	原疾患	医学的緊急度	登録～移植期間	ドナー	血液型	移植片	冷阻血時間	手術時間	転機
1	17日	2.4	劇症肝炎	10点	8日	20歳代	適合	縮小外側	6時間18分	7時間22分	生存
2	8カ月	7.3	劇症肝炎	10点	2日	60歳代	不適合	外側	6時間54分	6時間51分	生存 (生体再肝移植)
3	8カ月	8.8	移植後肝不全	10点	7日	20歳代	不適合	外側	8時間21分	9時間5分	生存
4	11カ月	7.1	胆道閉鎖症	6点	44日	30歳代	一致	外側	4時間56分	5時間58分	生存
5	9歳	32	劇症肝炎	10点	2日	40歳代	一致	左葉	5時間34分	9時間41分	生存
6	15歳	55	原発性硬化性胆管炎	6点	218日	20歳以下	一致	右葉	8時間3分	13時間10分	生存

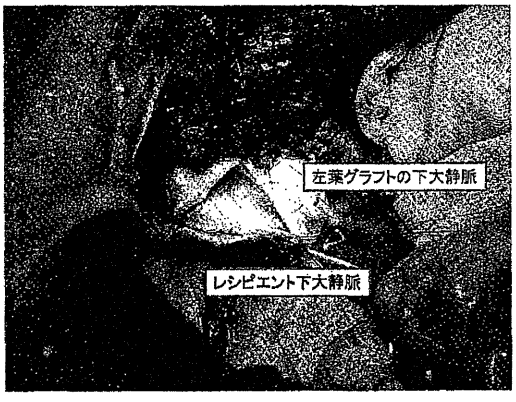

図2　下大静脈のSide to side吻合
レシピエント下大静脈を全遮断し，下大静脈付き左葉グラフトの下大静脈とSide to sideに吻合を行った．

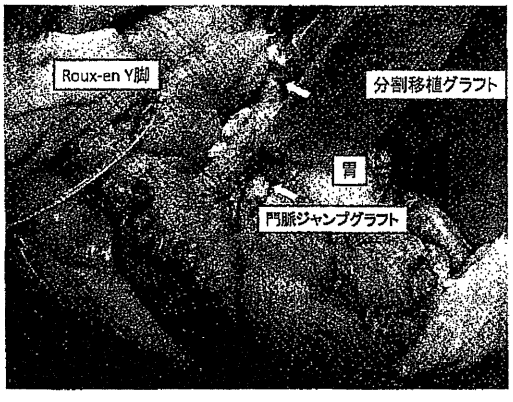

図3　門脈ジャンプグラフト再建
膵下縁の上腸間膜静脈・脾静脈合流部に脳死ドナー外腸骨静脈を間置し，膵前面を通す門脈ジャンプグラフト（矢印）で門脈再建を行った．

であった症例5, 6では，Side to sideで静脈吻合を行った（図2）．生体肝移植後肝不全が原疾患で分割肝移植による再移植を行った症例3では，初回生体肝移植時の門脈再建に使用した生体ドナー下腸間膜静脈間置グラフト狭窄の治療で，門脈ステント留置術を施行後であった．このため肝門部でステント留置された門脈を縫合閉鎖し，膵下縁の上腸間膜静脈・脾静脈合流部に脳死ドナー外腸骨静脈を間置し，膵前面を通す門脈ジャンプグラフトで門脈再建を行った（図3）．肝動脈再建は全例でレシピエント固有肝動脈と，移植片の左または右肝動脈を鏡視下に吻合した．胆道再建は全例で胆管空腸吻合を行った．手術時間は5時間58分から13時間10分であった．症例2では術後経過は非常に良好であったが，脳死分割肝移植28日後にVenoocclusive diseaseに伴う移植肝不全を発症した．肝静脈ステント留置を行ったが，急速に肝不全が進行したため術後31日で生体再肝移植を行った[11]．

移植後経過観察期間は2カ月から2年と比較的短いが，全例生存中である．

V. 考　察

分割肝移植は慢性的ドナー不足を解消する手段として1990年に開始された移植術式である[4,5]．欧米では分割肝移植は全脳死肝移植の約7～8%を占め，特に小児脳死肝移植の65%が分割肝移植で賄われている[12]．本邦では2010年7月の改正臓器移植法施行後から現在まで100症例の脳死肝提供があり，このうち9例で分割肝移植が実施されている．脳死肝移植の症例数はいまだ少ないが，多くの移植外科医の努力および脳死肝移植施設間の良好な関係のもとに，分割肝移植の実施率は欧米と比較して遜色がないと言える．

分割肝移植のドナー適応条件は，年齢50歳未満，脂肪肝なし，集中治療室滞在5日以内，昇圧剤使用が

少量，冷阻血時間6時間以内等が報告されている[13]．本邦では脳死ドナー発生後，安全で良好な臓器提供を目的に移植コンサルタント医によるドナー管理が行われており，欧米の分割肝移植適応よりも広い基準で実施できる可能性がある[14]．分割肝移植のレシピエント適応条件は，重度肝障害症例，高度門脈圧亢進症例，再移植症例，多臓器移植症例等を除外条件としていることが多い[14]．当施設で分割肝移植を実施した6例では，4例（劇症肝炎3例，移植後肝不全1例）が分割肝移植前に人工呼吸・血液ろ過透析・血漿交換等のLife supportを要する重症肝不全患者であった．比較的厳しいレシピエント条件であったが，6例全例でレシピエント生存しており，本邦における脳死分割肝移植の初期経験としては良好な成績であったと考えられる．

先達の努力により，本邦における脳死肝移植症例数は2010年7月の改正脳死法案後に増加傾向にある．さらに脳死肝移植症例を増やす手段として，分割肝移植は適応を厳選すれば有効な治療手段である可能性が示唆された．分割肝移植は尊い脳死臓器提供者・ご家族の意思，さらに多くの移植施設の協力があって実施可能な治療手段である．今回分割肝移植を協力して実施していただいた，京都大学，名古屋大学，熊本大学に深謝する．分割肝移植が広く安全に実施され，より多くの末期肝疾患患者が救命されるよう，今後も謙虚に経験を積み重ねていきたいと考えている．

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利益相反：なし

自施設における小児脳死分割肝移植6例の成績

INITIAL EXPERIENCE OF SPLIT LIVER TRANSPLANTATION IN NATIONAL CENTER FOR CHILD HEALTH AND DEVELOPMENT, JAPAN

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Purpose : We reviewed our initial experience of deceased split liver transplantation in National Center for Child Health and Development and report the results herein.

Subjects and methods : We have listed 50 patients with end-stage liver disease for deceased liver transplantation, and done 6 cases of split liver transplantation during October 2010 through October 2012. Variables including indication of liver transplantation outcome were reviewed.

Results : The indication for split liver transplantation was acute liver failure in 4, re-transplantation in 1 and primary sclerosing cholangitis in 1. The age of recipient ranged 17days～15yeras and body weight ranged 2.4kg～55kg. The split grafts were hyper-reduced left lateral segment in 1, left lateral segment in 3, left lobe in 1 and right lobe in 1. Although case #2 received retransplantation with living donor, all the patients are currently doing well with acceptable liver function with minimum follow-up of 2 months.

Conclusion : Satisfactory result can be achieved on initial experience of split liver transplantation in National Center for Child Health and Development. The follow-up period was too short to make definitive conclusion, however, split liver transplantation could be expand potential donor pool and may reduce the waiting list mortality without alterations of the results.

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症例報告

6歳未満小児脳死ドナーからの全肝移植の経験

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キーワード　小児脳死ドナー，肝移植，脳死肝移植

I. 内容要旨

臓器移植法改正後，15歳未満の小児からの脳死下臓器提供が可能となったがいまだその数は少ない．今回，6歳未満の小児からの脳死下臓器提供による肝移植術を経験したので報告する．症例は9カ月　女児．胆道閉鎖症にて生体肝移植術を行ったが，血流障害によるグラフト機能不全となり，術後42日目に脳死肝移植登録を行った．術後49日目に6歳未満の脳死ドナーから臓器提供を受け，脳死肝移植術を施行した．術前画像評価にて肝臓や血管のサイズを確認し，手術器械やカニューレなどの携行品を選択した．また，再移植術時の血行再建術に備えて血管グラフトを十分に採取した．再移植術後の経過は良好で，再移植術後172日目に軽快退院し，現在外来通院中である．小児脳死ドナーの臓器摘出時には臓器の大きさや血管径のバリエーションを想定した周到な手術器具類の準備と，レシピエント状態を考慮したグラフト選択や血行再建法など入念な手術計画が重要である．

II. はじめに

2010年7月改正臓器移植法が成立し15歳未満の小児からの脳死下臓器提供が可能となったが[1]，法改正後約2年が経過し6歳未満の小児からの臓器提供事例はなかった，今回本邦初の6歳未満の小児からの脳死下臓器提供による肝移植術を経験したので報告する．

III. 症　例

1．生体肝移植術および術後経過（図1）

9カ月　女児．胆道閉鎖症葛西手術後の減黄不良に伴う肝不全に対して，生体肝移植術を施行した．術後7日目（POD 7）より門脈血流の低下を認め，急性拒絶反応を考慮しステロイドパルス療法を施行したが，MRSAによる敗血症性ショックとなり集中治療を要した．その後，門脈血流低下に伴う肝機能不全が進行し，POD 33に経皮経肝的門脈造影を施行し，門脈吻合部狭窄および側副血行路の発達に対して門脈血管拡張術および側副血行路に対するコイル塞栓術を施行した．しかし，その後も門脈血流は改善せず，遠肝性となったため生体肝移植術後グラフト機能不全の診断にて，POD 42に脳死肝移植の登録申請を行い，医学的緊急性10点にて待機リストに登録された．

2．脳死下ドナー臓器摘出術

脳死肝移植登録より7日後に北信越地方の病院にて，6歳未満　男児　脳死ドナー（血液型不適合）より臓器提供があり，本症例が肝移植第一候補者として選定された．摘出臓器は心・肝・腎であった．脳死ドナー画像情報にて肝臓のサイズ，腹部大動脈径，肝動脈の走行を確認した．腹部大動脈からの臓器保存液灌流用カニューレサイズは14Fr.を選択した．横隔膜上にて下大静脈（IVC）を切開し右胸腔内へ脱血した．脾臓摘出がなかったため，門脈は上腸間膜静脈と脾静

DECEASED DONOR LIVER TRANSPLANTATION RECEIVING A LIVER FROM A CHILD UNDER SIX YEARS OLD : AN EXPERIENCE OF ORGAN RETRIEVAL FROM A PEDIATRIC DONOR IN JAPAN

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