Abstract

Background: Left lateral segment grafts are generally used for very young pediatric patients undergoing living donor liver transplantation (LDLT). Recently, graft reduction techniques were developed for LDLT. Monosegment grafting has been used in newborns. We studied the usefulness of monosegment grafting for infants.

Methods: Recipients under 2 years of age who underwent LDLT with a monosegment graft between 2010 and 2020 were gathered. Parents comprised all LDLT donors. A segment 2 monosegment graft was resected as a graft from the donor. Standard liver volume (SLV) was estimated using Urata's equation. Graft type, graft weight (GW), and native liver weight were assessed.

Results: Eight patients were included in the study. Original diseases consisted of biliary atresia (n=6) and fulminant hepatitis (n=2). Final graft type included monosegment (n=5) and reduced monosegment (n=3). Median final GW/body weight after reduction was 3.0% (range, 2.0% to 3.4%). Median native liver weight/SLV was 134% except in patients with fulminant hepatitis. Median pre-reduction GV/estimated GV was 113% (range, 60% to 208%). Median pre reduction GV/SLV of monosegment grafts that required reduction (n=3) was 109% (range, 106% to 121%). Median final reduced graft GV/SLV was 80% (range, 74% to 91%). Complications due to large-for-size grafts were not observed. One case of bile leakage

due to graft reduction occurred as a complication. Grafts were functioning well except for one graft loss due to antibody-mediated rejection.

Conclusions: Estimated GV in infants varies widely. Monosegment grafting can be useful for infants as well as newborns.

Introduction

Left lateral segment (LLS) grafts are generally used for pediatric living donor liver transplantation (LDLT). Graft recipients under 1 year of age with a graft-to-recipient weight ratio (GRWR) >4.0% have significantly reduced survival due to problems associated with large-for-size grafts [1]. Therefore, split and reduced grafts have been developed for pediatric recipients. These techniques have expanded the donor pool and decreased waiting-list mortality for children awaiting cadaveric donor transplantation [2]. Recently, graft reduction techniques have been developed for LDLT as well.

To overcome this critical large-for-size graft problem, advanced techniques have been developed to further reduce graft size in pediatric LDLT, especially for neonates or smaller infants [3, 4]. A monosegment graft was developed for graft reduction. This procedure was applied to newborns at first before being gradually applied to infants. The monosegment is created at the time of donor surgery. Therefore, preoperative graft size estimation and selection are important. Recent studies have shown the effect of GRWR on liver transplantation; however, preoperative graft size was measured with volumetry based on standard liver volume (SLV). We studied the usefulness of monosegment grafting for infants based on graft volumetry and GRWR.

Methods

Recipients of a monosegment graft in LDLT under 2 years of age between 2010 and 2020 were included. Newborn (under 1 month old) was excluded. Parents comprised all LDLT donors. Patients received a standard tacrolimus formulation with a steroid taper. Living donors were screened with imaging evaluations including abdominal computed tomography (CT) and ultrasound. Analysis of total liver volume and graft volume (GV) were performed with Synapse Vincent software (Fujifilm, Tokyo, Japan). SLV was estimated using Urata's equation: SLV(ml)=706.2×Body surface Area (m^2)+2.4 [5]. Liver specific gravity was approximated to 1.0 g/ml.

A segment 2 (S2) monosegment graft was resected from the donor. The donor LLS was reduced in situ as described previously [3]. After isolation of the LLS graft, portal vein 3 was exposed and occluded to make demarcation lines on the surface between S2 and segment 3 (S3). Further parenchymal transection was performed following the demarcation lines. If further reduction from the perspective of graft volume was necessary, the lateral part of segment 2 was also removed [6]. During the recipient operation, all of the vascular and biliary reconstructions were performed as in the standard pediatric LDLT procedure.

Patients' medical records were reviewed retrospectively to collect the following data: graft type, graft weight (GW), native liver weight, and postoperative laboratory data

including alanine aminotransferase (ALT), prothrombin time-international normalized ratio (PT-INR), albumin and total bilirubin at 1, 2, 4 and 12 weeks post-LDLT. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki Congress and the Istanbul declaration regarding donor source regarding donor source. Donors must not be from prisoners, or from those individuals who are coerced or paid.

Results

Eight patients were included. Original diseases consisted of biliary atresia (n=6) and fulminant hepatitis (n=2). Final graft types included monosegment (n=4) and reduced monosegment (n=4). A summary of the patients is provided in Table 1. Median final GW/body weight ratio after reduction was 3.0% (range, 2.0% to 3.4%) at the time of LDLT. Median native liver weight/SLV was 134% (range, 123% to 162%), except in patients with fulminant hepatitis. Median pre-reduction (GV) /estimated GV was 113% (range, 60% to 208%) at the time of preoperative donor evaluation. Estimated GV was fluctuated widely. Measured GW tend to be larger than estimated GV in small graft. These results are plotted in Fig 1. Median pre reduction GV/SLV of monosegment grafts that required reduction (n=3) at the time of LDLT was 109% (range, 106% to 121%). Median final reduced graft GV/SLV was 80% (range,

74% to 91%).

Complications due to large-for-size grafts were not observed, including inability to close the abdomen and poor graft perfusion. One case of bile leakage due to graft reduction occurred as a complication. ALT decreased rapidly within 2 weeks. PT-INR, albumin, and total bilirubin levels improved during the 12 weeks after LDLT (Fig 2). Grafts were functioning well, except for one graft loss due to antibody-mediated rejection.

Discussion

Proper graft size in pediatric LDLT remains controversial. When general GRWR exceeds 4.0% in neonates and smaller infants receiving LLS grafts, the risk of morbidity increases [3]. Another study suggested that GRWR between 1.9% and 5.8% would not cause noticeably more adverse events for infants weighing ≤8 kg who undergo LDLT [7]. Bonatti et al reported two major complications resulting from large-for-size grafts. One is poor graft perfusion, which can cause graft dysfunction. The other is inability to close the abdominal wall, which can cause graft compression or diaphragmatic splinting. If the abdomen is unable to be closed, temporary abdominal closure using a silastic patch is required [8]. Complications from large-for-size grafts can occur at these sizes as well. Thus, grafts with GRWR <4.0% might be more suitable than previously thought. However, a reduction in graft mass might

still be considered an applicable strategy for select patients.

In contrast, several studies maintain that GRWR should be at least 1% in adult LDLT. Small-for-size grafts are less likely to occur in pediatric LDLT. Li et al reported that complications with the biliary enteric anastomosis were more frequently observed in recipients with GRWR <2% [9]. Therefore, GRWR >2.0% is suitable.

Due to the limited number of patients in our study, a reasonable range of GRWR for pediatric LDLT remains unknown. In our experience, recipients with GRWR ranging from 2.0% to 3.4% for monosegment grafts had good results. Thus, we suggest that even with preparation of a monosegment graft, GRWR should be kept below 3.5%, even for infants.

However, graft volume estimation was performed based on volumetry and SLV, not GRWR [5]. Our study showed that LLS reduction was considered when estimated graft volume was <100% of SLV, not when estimated GRWR of the donor LLS was >4.0%. Regardless of graft type, adequate preoperative assessment is important. Estimated graft volume corroborates large variation in the size of liver segments, even in healthy living donors. Accurate volumetry of the donor's liver by CT before LDLT is crucial. In our experience, additional graft redaction was required in two patients because the actual graft volume was larger than the estimated graft volume. More accurate assessment of graft volume is needed. In our study, graft volume was 74–91% and GRWR was 2.0–3.4%. At a minimum, it should

be smaller than SLV. It is desirable to consider monosegment grafting with SLV ≥100%.

Serum ALT and TB levels decreased and PT-INR and ALB improved during the first 12 weeks after LDLT. The decrease in hepatic enzyme levels indicates no problems with graft size because the liver damage is within the range and hepatic synthesis recovered rapidly. In this study, one patient experienced prolonged bile leakage from the cut surface. The monosegment graft has a larger cut surface than the LLS. This complication should be predictable.

Conclusions

Estimated GV in infants varies widely. Our data suggested that monosegment grafting may be chosen with estimated GV >100%. We concluded that monosegment grafting can be useful for infants as well as newborns.

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