Abdominal Wall Closure in Less Than One-Year-Old Pediatric Liver Transplant Recipients

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Abstract

Aim: The discrepancy between size of the graft and capacity of the abdominal cavity appears to be a critical problem for liver transplantation (LTx) in infants. Staged closure techniques with the help of synthetic or biologic materials enables successful LTx even in the presence of additional surgical interventions. In this study, we aimed to analyze the effects of primary (PC) or delayed closure (DAC) of the abdomen on graft and patient outcomes in pediatric LTx patients less than one-year of age.

Methods: The hospital records of all pediatric patients less than one-year-old with minimum 6-months follow-up period who received primary LTx in Liver Transplantation Institute at İnönü University were analyzed retrospectively for the patient and allograft characteristics, abdominal closure techniques, postoperative complications and outcomes.

Results: PC was achieved in 10 patients. Bogota bag closure was performed in 28 and skin only closure was implemented in 3 patients. The DAC group showed statistically significant higher GRWR values. The patient survival rates for PC and DAC groups were not statistically significant.

Conclusions: High DAC rate was attributed to the infant patient population similar to the literature regarding low body weight LTx recipients. Patient survival did not differ in PC and DAC groups supporting results of the current studies. Staged abdominal wall closure enables the LTx of very small pediatric patients safely. Future directions may comprise enhanced graft modifications and creation of more durable, inert and accessible biomaterials minimizing the re-operation requirements.

Keywords: *Children; liver transplantation; abdominal closure*

1. Introduction

Liver transplantation (LTx) under one-year-old children presents distinctive challenges despite the prominent improvements in pediatric LTx field over the last 2 decades. Overall patient and graft survival rates have been reported more than 80% as a result of enhanced multidisciplinary care including surgical techniques, immunosuppressive treatment modalities and peri- and post-operative management of the pediatric recipients.[1-5]

LTx indications in infants mainly comprise biliary atresia as the most common cause, inherited metabolic disorders, acute liver failure and other congenital cholestatic liver diseases. Split allografts from deceased donors and technical variant grafts from living donations have been introduced especially for this group of patients with the scarcity of the size-matched organs. Eastern countries including Türkiye, Japan, Korea and India have to rely on living donor LTx (LDLT) while North American and European countries predominantly utilize split grafts due to donor obtainability dynamics. In anyways, the discrepancy between size of the graft and capacity of the abdominal cavity appear to be a critical problem for these very small children. Large size allografts were associated with hemodynamic and mechanical risks regarding insufficient perfusion of the graft, kinking and distortion of the vasculature, elevated intra-abdominal pressure and struggles with abdominal wall closure. The value of more than 4% graft weight to recipient body weight ratio (GRWR) has been linked to "large-for-size syndrome" with poor outcomes which is a high probability condition in infants and children less than 10 kg body weight. Closure of the abdomen with increased intra-abdominal pressure impairs organ perfusions including the allograft and directly affects the graft and patient survivals. Delayed abdominal closure (DAC) techniques were introduced in this context besides working on lower GRWR graft techniques. Temporary skin closure, silastic silo or "Bogota bag" application and the use of synthetic or biologic meshes have been presented for staged abdominal wall closure which enables the transplantation of small pediatric patients safely.[3-9]

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In this single center study, we aimed to analyze the abdominal closure techniques and effects of primary or delayed closure of the abdomen on graft and patient outcomes in pediatric liver transplant recipients less than one-year of age.

2. Materials and Methods

The hospital records of all pediatric patients less than one-year-old with minimum 6-months post-transplant follow-up period, who underwent primary LTx in Liver Transplantation Institute at İnönü University, Malatya, Turkiye were analyzed retrospectively for the patient and allograft characteristics, abdominal closure techniques, early and late postoperative complications and patient and graft survival.

Age, gender, weight, GRWR, transplant indication, allograft type, source of the graft (live donor, deceased donor), presence of surgical complication which required laparotomy, reason for staged abdominal closure and, patient and graft loss were compared between primary fascial closure (PC) and DAC (skin only closure, Bogota bag application, mixed skin and Bogota bag closure) groups. Statistical analysis was performed with SPSS, version 28.0 for Windows software (Statistical Package for Social Sciences, SPSS, Inc) for descriptive statistics of the groups and comparison of the variables by independent-samples t-test, Mann-Whitney U test and, Pearson chi-squared or Fisher's exact test. Kaplan-Meier method was used for evaluation of patient and graft survivals. A p-value <0.05 was considered as statistically significant.

This study was approved by the Institutional Review Board of Inonu University with 2025/8251 number.

Picture 1

Patient with vertical Bogota bag and transverse skin-only closure.

3. Results

A total of 57 liver transplantations were performed in 55 infants between 2010 and January 2025 with minimum of 6 months post-transplant follow-up period in Liver Transplantation Institute at İnönü University. Six patients were excluded from the study due to absence of related data.

The mean age at LTx was 7.86±3.88 months (range 4-12 months) with mean weight of 6.97±2.62 kg (range 4-10 kg) and, 45%of the patients were female and 55% were male. Major LTx indication was biliary atresia (n=18, 37%) and other cholestatic liver diseases (n=18, 37 %). Most common graft types were left lateral segment (LLS, n=26, 53%) and reduced size left lateral segment (n=21, 43%).

Decision for DAC was made according to the perioperative Doppler Ultrasonography (DUS) findings towards the end of the operation when skin and fascia were approximated. Bogota bag creation with a sterile IV serum saline bag or skin only closure was applied if the portal vein mean peak systolic velocity was below 15 cm/sec with patent vasculature.

Primary fascial closure was achieved in 10 patients (20.4%) Bogota bag and skin only closures were performed in 28 (57.1%) and 3 (6.1%) patients respectively. Vertical Bogota bag and transverse skin only closure (Picture-1) were implemented in 8 patients (16.3%). In one PC patient, Bogota bag was implemented following an intestinal perforation. Partial Bogota bag was applied in another patient with skin only closure after an internal herniation of the small bowel occurred. Incisions of all the patients in this study with DAC were healed over granulation tissue except with one patient who required split thickness skin grafting and one patient died with Bogota bag on place.

The results included 31 patients with GRWR>3 and 7 patients with GRWR>4 values. The DAC group showed statistically significant higher GRWR values with GRWR≥3 in 28 patients and GRWR>4 in 6 patients.

The median revision number for DAC was 1 (range 0-4). There was no accurate data regarding the time to obtain definitive closure of the incisions in DAC patients. Number of patients who had surgical complications which required laparotomy was 26 (53%) and most frequent surgical complication was intestinal perforation (n=13, 26%), evisceration (n=5, 10%) and ileus (n=4, 8%). There was only one vascular complication in a DAC patient with Bogota Bag. Portal vein thrombosis occurred in post-transplant day-1 and thrombectomy and renewal of the anastomosis was made successfully. There were no surgical wound infections in any of the patients, but evisceration happened in 5 patients including one PC and 3 DAC patients.

There were 2 liver re-transplantations because of biliary complications and chronic allograft rejection. Out of 49 patients with minimum 6 months follow up period, 8 patient was lost due to multiorgan failure following re-transplantation (n=1) and gastrointestinal infection related sepsis (n=1). There was no information available about the cause of 5 mortalities. Kaplan- Meier patient survival rates for PC and DAC groups were 80% and 84.6% with no statistical significance (Log Rank test p-value 0.71) in the median post-transplant follow-up time of 86 months (range 7-180 months). There was no statistically significant difference between PC and DAC groups regarding gender, age, body weight, liver transplant indication, graft type, presence of surgical complications and re-transplantation rate. GRWR values were significantly higher in DAC group (p=0.01)

Table-1 summarizes demographics data and clinical outcomes.

Table 1

Patient and graft characteristics (median, minimum and maximum values) and outcomes.

	Primary Fascial Closure	Delayed Abdominal Closure	*p*
Number(Percentage)	10 (20.4)	39 (79.6)	
Gender			
Female	5 (50%)	17 (43.6%)	
Male	5 (50%)	22 (56.4%)	
Age (months)	8.3 (range 5-11.2)	8.2 (range 3.9-11.6)	
Weight (kilograms)	7.2 (range 6-10)	6.8 (range 4-10)	
GRWR	2.7 (range 2.3-3.4)	3.2 (range 1.8-5.1)	0.01
LTx indications			
Biliary atresia	4 (40%)	14 (36%)	
Metabolic disorders	1 (10%)	6 (15%)	
Acute liver failure	1 (10%)	5 (13%)	
Cholestatic diseases	4 (40%)	14 (36%)	
Graft type			
LDLT, LLS	6 (60%)	20 (51.3%)	
LDLT, reduced LLS	3 (30%)	18 (46.1%)	
Whole liver	1 (10%)	0	
Split liver right lobe	0	1 (2.6%)	
Number of Bogota bag revision	-	1 (range 0-5)	
Presence of surgical complications	3 (30%)	23 (58.9%)	
Re-transplantation	0	2 (5%)	
Overall patient survival	80%	84.6%	

4. Discussion

Surgical revolutions and limitations by fundamental principles of human physiology outline the management of abdominal wall closure in infant recipients of LTx. Despite the utilization of reduced left lateral segments and mono-segments, hemodynamic stability with well perfused liver graft and vital intra-abdominal organs guide the surgeons for the decision of proper abdominal closure. Staged closure techniques with the help of synthetic or biologic materials enable successful LTx in very small size patient populations even in the presence of additional surgical interventions. According to the literature, delayed abdominal closure is an applicable approach to overcome the "large-for-size" and catastrophic consequences like abdominal compartment syndrome (ACS) scenarios with similar outcomes compared to primary closure cases[1-9].

Primary fascial closure cannot be achieved approximately in 20-25% of the pediatric LTx recipients. Preventative planning is a reasonable strategy with evaluation of the graft and recipient size matchings by using GRWR, measurements of the anterior-posterior abdominal diameter and graft thickness, and 3-dimentional models to prepare the team for potential difficulties that might jeopardize the success of the whole operation. These easily accessible parameters might be beneficial for the decision of further reduction of the liver graft and/or prearrangement of the certain materials for abdominal closure in the operating room. Hyper-reduction of the left lateral segment or using mono-segments have been introduced and mastered by Japanese centers in living donor allografts to avoid the volume related problems including abdominal wall closure however, there have been reports revealing risks of further transections such as biliary complications, potential graft ischemia, "small-for-size syndrome", increased donor surgery time and donor morbidity[3,5,7,10,11]. Eventually, it is the decision of the surgical team to choose the additional trimming or delayed abdominal wall closure for each case individually. The DAC rate was 79.6% in our study population including only infant LTx recipients. The DAC group presented statistically significant higher GRWR values as expected with GRWR≥3 in 28 (78%) patients and GRWR>4 in 6 patients. Molino et al and Costa et al presented similar results regarding >70% DAC in low body weight patients with higher GRWR values.[8,11] We performed only 2 deceased donor LTs in this series showing our dependence on LDLT. Almost half of the DAC group received reduced LLS grafts. Mono-segment grafts might help further reduction of the GRWR values with higher possibility of PC.

Very early post-transplant period in the ICU is very critical for the signs of the ACS. Stretched abdomen in physical examination and increased abdominal girth, escalation in ventilatory pressure support, increased and persisted intra-abdominal pressure, decreased urinary output are the warning signs for ACS and re-operation threshold must be kept very low. In critically ill infants upper limit for intra-abdominal pressure is accepted as 10 mmHg which is usually measured by 3-way Foley catheter[13-14]. In our study there was no patient with the signs of intra-abdominal compartment syndrome and no requirement of abdominal closure revision related to that.

Common methods of staged closure have been reported as skin-only closure, delayed closures with the use of silastic silo or "Bogota bag" and surgical meshes consisting of synthetic (non-absorbable expanded polytetrafluoroethylene, absorbable Vicryl meshes) and biologic (acellular dermal matrix) meshes. The usage of vacuum assisted closure (VAC) devices, heterotopic auxiliary placement of the liver graft, utilization of the donor's abdominal wall as vascularized graft accompanied by the donated organs have presented as rare procedures in pediatric liver and multivisceral transplant patients due to additional complex surgical and immunological considerations. Meshes or silos have been more preferred materials instead of VAC assisted closure in the very early post-operative period especially regarding the risks of intestinal fistula and damage to the graft surface. Acellular porcine or human derived biologic dermal matrices were developed with the requirement for enduring, flexible, pliable, infection resistant and absorbable materials considering their integrating nature into the native human tissues in the growing body[15-22]. Gül-Klein et al reported 16 out of 21 abdominal wall closure patients under 2 years old with the use of biologic mesh[16]. Only one mesh had to be removed secondary to infection and 2 abdominal wall hernias occurred in the long term. Molino et al stated no complications in their practice with biological materials[12]. Unfortunately, the cost of the biologic materials seems to be the main struggle in spite of their promising temporary or permanent role in tension-free abdominal closure. We did not have any experience with ePTFE, Vicryl or acellular dermal matrices due to financial reasons.

Staged abdominal closure is one of the critical opportunities

which enables LTx in infants with the benefits of tension free closure outweighing the risks for aditional interventions. Decision of the most proper closure technique varies according to the several parameters including size mismatch, perfusion of the allograft and other vital organs and ventilation status of the patient. The main parameter affected our decision for DAC was the DUS findings at time of abdominal closure although we monitor our patients' ventilation status and intra-abdominal pressures closely considering the need for switching from PC to DAC in the ICU[7-12].

Patient and graft survival rates have not differed in PC and DAC patients according to the literature[7,8,12]. Our results correlated with the similar reports revealing more than 80% patient survival in both groups with no statistically significant difference. Presence of surgical complications also did not differ regarding abdominal closure status.

This study has potential limitations. Our analysis did not contain the information regarding post-transplant very early patient mortalities and related complications since we decided to evaluate the events through the DAC stages with the early post-transplant survivors. We believe that a more comprehensive analysis comparing both episodes would contribute valuable knowledge to the current literature.

5. Conclusion

The abdominal wall closure in pediatric LTx patients less than one year of age required to be planned meticulously with proper techniques since it directly affects the graft and patient outcomes. Infant liver recipients are more prone to have increased intra-abdominal pressure due to graft and abdominal cavity size mismatch. DAC is more frequently implemented in infants with higher GRWR values within the same age group. DAC with or without the use of prosthetic materials is a safe way for abdominal closure in infant LTx operations with similar survival rates compared to primary fascial closure.

Future directions may comprise enhanced graft modifications and creation of more durable, inert and accessible biomaterials minimizing the evisceration, herniation, re-operation requirements.

Statement of ethics

This prospective study was approved by Institutional Review Board of Inonu University with 2025/8251. Authors declare that the study was conducted in accordance with the Declaration of Helsinki and followed the ethical standards of Turkey.

genAI

No artificial intelligence-based tools or generative AI technologies were used in this study. The entire content of the manuscript was originally prepared, reviewed, and approved by both authors.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

Data and materials are available to the researchers.

Author contributions

Concept, Design, Supervision (NÇ, SU, SK, CK, SY), Data Collection and/or Processing (NÇ), Analysis and/or Interpretation (NÇ), literature review (NÇ), writer (NÇ), critical review (NÇ, SY). Both authors read and approved the final manuscript.

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