Preoperative Ascites and/or Pleural Effusion Was a Predictor of Massive Albumin Use After Liver Transplantation

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ABSTRACT

Background: Albumin (Alb) is often administered for patients undergoing liver transplantation (LT). However, the current status of Alb use after LT is unclear. We examined the current status of postoperative Alb administration and factors associated with massive Alb use after LT.

Methods: A total of 122 consecutive patients who underwent adult-to-adult LT between January 2013 and August 2017 were divided into 2 groups according to total amount of Alb used after LT: High group, Alb $\geq$ 1000 g; and Low group, Alb <1000 g. Characteristics of postoperative Alb use in living-donor LT (LDLT) and deceased donor LT (DDLT) were compared. Moreover, independent predictive factors for massive Alb administration after LDLT were analyzed.

Results: The amount of postoperative Alb use did not differ between LDLT and DDLT. In the High group, days of Alb administration and maximum daily volume of ascites discharge were significantly higher, cases with preoperative ascites and/or pleural effusion were more frequent, incidences of cytomegalovirus infection and bacteremia were higher, and prothrombin time-international normalized ratio was longer compared with the Low group. Preoperative ascites and/or pleural effusion was an independent predictive factor before LT.

Conclusion: Preoperative ascites and/or pleural effusion was a predictor of massive Alb use after LT.

Key words: albumin, ascites, liver transplantation

Abbreviations:

Alb - albumin;
ACR - acute cellular rejection;
CART - cell-free and concentrated ascites reinfusion therapy;
CIT - cold ischemic time;
CMV - cytomegalovirus;
CT - computed tomography;
ICU - intensive care unit;
LD - living donor;
LT - liver transplantation;
GRWR - graft/recipient body weight ratio;
MELD - model for end-stage liver disease;
OR - odds ratio;
POD - postoperative day;
PT-INR - prothrombin time-international normalized ratio;
SMI - skeletal muscle mass index;
T-Bil - total bilirubin WBC, white blood cell;
WIT - warm ischemic time.

INTRODUCTION

Ascites is a major characteristic of patients with decompensated liver cirrhosis and is associated with poor prognosis (1). With moderate to massive postoperative ascites retention, administration of serum albumin (Alb) is effective for reducing ascites via urination. Liver transplantation (LT) is a curative treatment for patients with end-stage liver diseases, including decompensated liver cirrhosis. However, patients who undergo LT sometimes experience moderate to massive postoperative ascites retention, although LT theoretically resolves the hyperdynamic status and hypoalbuminemia associated with

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decompensated liver cirrhosis. For such patients, Alb supplementation is necessary to reduce ascites and systemic edema.

Moreover, posttransplant hypoalbuminemia has a negative impact on kidney function and outcomes after LT (2,3). Ertmer et al. reported that continuous Alb infusion preserved cumulative organ function, particularly cardiovascular function, after LT (4). Alb is thought to interact with the endothelial glycocalyx, a highly-hydrated fibrous meshwork of carbohydrates, which lines the luminal side of the vascular endothelium and plays an important role in vascular wall homeostasis (5). The glycocalyx is easily damaged, with causes such as major surgery, decreasing vascular barrier function and causing protein extravasation, tissue edema, and accelerated inflammation. Preservation of a damaged glycocalyx therefore reflects future inflammatory and oxidative responses (6). Decreases in circulating Alb follow the loss of glycocalyx, leading to increased fluid extravasation (7). Stevens et al. revealed that Alb can assist in maintaining endothelial barrier function (8). Alb is therefore considered indispensable for perioperative management after LT, because damage to the glycocalyx may be restricted by maintaining the concentration of Alb. On the other hand, reducing post-transplant Alb would be economically desirable. However, little is known about the current status of Alb use and predictors of high Alb use after LT.

The present study examined the current status of postoperative Alb administration in both living-donor LT (LDLT) and deceased-donor LT (DDLT) and risk factors of massive Alb use after LDLT.

PATIENTS AND METHODS

Patients

Between January 2013 and August 2017, a total of 122 consecutive patients who underwent adult-to-adult LT, including 103 LDLTs and 19 DDLTs, at Kyoto University Hospital were enrolled to this retrospective study. This study (R1473-1) was approved by the ethics committee at Kyoto University, and conducted in accordance with the Declaration of Helsinki of 2000.

Surgical procedures and perioperative management

Surgical techniques for both donors and recipients are described elsewhere (9,10). Perioperative management is also described elsewhere (11,12).

Assessment of body composition

Preoperative plain computed tomography (CT) was performed by a multidetector CT scanner (Aquilion 64; Toshiba Medical Systems, Tochigi, Japan). The details about skeletal muscle mass index (SMI) are described elsewhere (11). Quality of skeletal muscle was evaluated by intramuscular adipose tissue content (IMAC), calculated by dividing the CT value of the multifidus muscles by the CT value for subcutaneous fat at the L3 level. Visceral adiposity was evaluated as the visceral-to-subcutaneous adipose tissue area ratio (VSR). Visceral and subcutaneous adipose tissue areas were calculated as areas of -150 to -50 HU and -190 to -30 HU, respectively. Optimal cut-offs for SMI, IMAC, and VSR for males and females were determined separately based on data from a large number of healthy LDLT donors (13,14).

Analyzed parameters

First, we compared characteristics of postoperative Alb use between LDLT and DDLT. Next, patients were divided into 2 groups according to the total amount of Alb administration after LT: High group, Alb ≥ 1000 g; and Low group, Alb < 1000 g. The following were made comparison between 2 groups: age, gender, underlying liver disease, Child-Pugh classification, model for end-stage liver disease (MELD) score, ABO incompatibility, retransplantation, presence of preoperative ascites and/or pleural effusion, preoperative massive ascites and/or pleural effusion, body composition (SMI, IMAC, VSR), surgical data such as graft type, graft-to-recipient body weight ratio (GRWR), operation time, blood loss, warm ischemic time (WIT), cold ischemic time (CIT), serum levels on postoperative day (POD) 7 for white blood cells (WBC), platelets, C-reactive protein (CRP), prothrombin time-international normalized ratio (PT-INR), aspartate transaminase (AST), alanine aminotransferase (ALT), total bilirubin (T-Bil), Alb, and creatinine (Cre), the maximum daily volume of ascites, postoperative date of the maximum daily volume of ascites, duration of Alb administration, maximum daily dose of Alb, period of stay in the intensive care unit (ICU), incidence of re-operation, acute cellular rejection, bacteremia, and cytomegalovirus (CMV) infection. The isolation of bacteria related with signs of infection or clinical symptoms (e.g., fever $> 38^{\circ}\text{C}$) other than common skin contaminants within 90 days after transplantation was defined as bacteremia. Moreover, independent predictive factors of massive Alb administration after LDLT were analyzed.

Statistical analysis

Continuous data are presented as medians with ranges. Patient characteristics were compared between groups with the Fisher's exact test or χ^2 test for categorical variables, and the Mann-Whitney U test or t-test for continuous variables. A p value of <0.05 or with p <0.10 in univariate analysis was considered candidates for multivariate analysis using multiple logistic regression modeling. Values of P <0.05 were regarded statistically significant. All statistical data were generated using JMP Pro version 12 software (SAS Institute, Cary, NC).

RESULTS

Duration of Alb administration, total dose of Alb administration, and maximum daily dose of Alb administration did not differ significantly between LDLT and DDLT (*table 1*).

Clinical and surgical characteristics of LDLT patients according to total Alb administration dose are shown in *table 2*. Among the preoperative data, existence of ascites and/or pleural effusion was significantly more frequent in the High group than in the Low group (P=0.007). Postoperative serum level for PT-INR, Alb, and Cre were significantly longer, lower, and higher in the High group than in the Low group (P=0.005, P= 0.025, and P <0.001, respectively). In the High group, duration of Alb administration and period of ICU stay were significantly longer (P<0.001 each), maximum amount of Alb administration and daily ascites discharge were significantly higher (P <0.001 each), and postoperative date of the maximum daily volume of ascites was significantly later (P <0.001) compared with the Low group. There was significant higher frequency of post-transplant CMV infection in the High group than in the Low group (P = 0.005).

Finally, we explored predictive factors of high Alb administration. Univariate analysis identified preoperative ascites and/or pleural effusion, longer PT-INR, higher serum level of Cre, lower serum levels of AST and Alb, massive amount of ascites, late postoperative

date of the maximum daily volume of ascites, longer ICU stay, and CMV infection as significant (P <0.05 each) predictive factors for massive Alb administration (*table 3*). Including variables with values of P <0.10 in univariate analysis, multivariate analysis identified preoperative ascites and/or pleural effusion, ICU stay >2 weeks, PT-INR ≥ 1.23 on POD 7, and date of maximum daily volume of ascites ≥ 10 days as independent factors of massive Alb administration (*table 4*). Among them, only preoperative ascites and/or pleural effusion was a factor before LT.

DISCUSSION

This retrospective study, as far as we know, provides the first examination of the actual status of postoperative Alb administration and clarified clinical characteristics for massive Alb use after LT. We showed that there were no significant differences between patients who underwent LDLT and DDLT regarding postoperative Alb administration. Interestingly, this finding indicates that graft liver volume is unrelated to postoperative Alb administration. We also confirmed that preoperative ascites and/or pleural effusion, ascites discharge peaking more than 10 days postoperatively together with ICU stay for >2 weeks and PT-INR ≥ 1.23 at POD 7 were closely related to postoperative administration of a large amount of Alb. Among them, preoperative ascites and/or pleural effusion was a predictor of massive Alb use after LT, since it only was a factor before LT. In contrast, the other 3 factors would reflect massive and persistent ascites discharge after LT.

The representative function of Alb is to maintain colloid osmotic pressure (15). Moreover, Alb binds to endocrine or exocrine products, drugs and their metabolites, by which Alb exerts important anti-oxidant, anti-inflammatory, anti-coagulant, and immune effects in the human body (14). However, patients with decompensated cirrhosis usually show quantitative hypoalbuminemia accompanied by a decreased capacity for Alb production and increased Alb leakage toward the intraperitoneal cavity. In addition, qualitative

Table 1 - Comparison of Alb use between LDLT and DDLT

	LDLT (n=103)	DDLT (n=19)	P
Duration of Alb administration (day)	25 [0-188]	15 [2-98]	0.213
Total dose of Alb administration (g)	788 [0-5225]	463 [63-2913]	0.377
Maximum daily dose of Alb administration (g)	50 [0-288]	50 [25-213]	0.427

Alb - albumin, DDLT - deceased donor liver transplantation, LDLT - living donor liver transplantation

Table 2 - Clinical and surgical characteristics of patients according to total amount of Alb used after LDLT

Characteristics	Low group(n=62)	High group(n=41)	P
Recipient age (years)	53 [21-68]	56 [22-68]	0.358
Recipient gender (male/female)	30/32	21/20	0.778
Donor age (years)	45 [20-67]	49 [21-64]	0.736
Underlying disease			0.441
Hepatocellular carcinoma	14	9	
Hepatitis B/C-related cirrhosis	10	11	
Cholestatic disease	14	9	
Others	24	12	
Child Pugh (A,B/C)	19/43	8/33	0.203
MELD	16 [4-39]	16 [8-42]	0.208
ABO compatibility			0.120
Identical, compatible/Incompatible	45/17	35/6	
Graft type (Right/Others)	40/22	21/20	0.180
GRWR (%)	0.90 [0.56-1.44]	0.86 [0.56-1.27]	0.473
Retransplantation	60 (97%)	41 (100%)	0.152
Preoperative ascites and/or pleural effusion	29 (47%)	30 (76%)	0.007
Preoperative massive ascites and/or pleural effusion	11 (18%)	11 (27%)	0.274
Preoperative low SMI	7 (11%)	7 (20%)	0.406
Preoperative high IMAC	21 (34%)	15 (37%)	0.778
Preoperative high VSR	12 (20%)	11 (27%)	0.376
Operation time (min)	905 [672-1734]	879 [619-1360]	0.236
Blood loss (ml)	5560 [920-67230]	6400 [500-24300]	0.357
Warm ischemic time (min)	43 [23-79]	48 [28-92]	0.237
Cold ischemic time (min)	104 [30-409]	111 [37-456]	0.320
WBC level at POD7 (10 ⁹ /L)	8.64 [2.48-35.42]	10.74 [1.67-32.24]	0.707
Platelet level at POD7 (10 ⁹ /L)	55 [16-232]	47 [16-280]	0.411
CRP level at POD7 (mg/dL)	3.5 [0.1-20.0]	2.7 [0.2-10.5]	0.309
PT-INR level at POD7	1.19 [1.00-3.36]	1.32 [0.90-2.36]	0.005
AST level at POD7 (U/L)	33 [15-2450]	43 [13-246]	0.592
ALT level at POD7 (U/L)	74 [21-2201]	54 [20-290]	0.142
T-Bil level at POD7 (mg/dL)	4.5 [0.7-15.3]	5.4 [1.1-18.4]	0.156
Alb level at POD7 (g/dL)	2.6 [2.2-3.7]	2.5 [1.8-3.9]	0.025
Cre level at POD7 (mg/dL)	0.62 [0.20-2.02]	0.91 [0.30-2.87]	<0.001
Maximum daily volume of ascites (ml)	2766 [498-23350]	10104 [1986-27588]	<0.001
Postoperative date of maximum daily volume of ascites (day)	7 [1-23]	12 [1-24]	<0.001
Duration of Alb administration (day)	17 [0-42]	46 [23-188]	<0.001
Maximum daily dose of Alb (g)	50.0 [0-237.5]	87.5 [37.5-287.5]	<0.001
Period of stay in the ICU (day)	13 [3-69]	23 [7-113]	<0.001
Incidence of re-operation (%)	11 (18%)	11 (27%)	0.274
Incidence of rejection (%)	32 (52%)	21 (51%)	0.969
Incidence of bacteremia (%)	15 (24%)	17 (42%)	0.065
Incidence of CMV infection (%)	30 (48%)	31 (76%)	0.005

Alb - albumin, ALT - alanine aminotransferase, AST - aspartate transaminase, CMV - cytomegalovirus, Cre - creatinine; CRP - C reactive protein, GRWR - graft/recipient body weight ratio, ICU - intensive care unit, IMAC - intramuscular adipose tissue content, LDLT - living donor liver transplantation, MELD - model for end-stage liver disease, POD - postoperative day, PT-INR - prothrombin time-international normalized ratio, SMI - skeletal muscle mass index, T-Bil - total bilirubin, VFA - visceral fat area, VSR - visceral to subcutaneous adipose tissue area ratio, WBC - white blood cell

hypoalbuminemia indicating a functional Alb disorder is seen in cirrhotic patients (16). Klammt et al. also reported that these functional disorders might induce

renal dysfunction, making the liver disease more serious (15,17). In the present study, most patients showed hypoalbuminemia despite receiving a new liver from a

Table 3 - Univariate analysis of factors of high Alb administration

Variable	Univariate		
	OR	95%CI	P
Recipient Age			
≥ 50 (n = 65)	2.104	0.911-5.083	0.082
< 50 (n = 38)	1.000		
Gender			
Male (n = 51)	1.120	0.778-0.508	0.778
Female (n = 52)	1.000		
Donor Age			
≥ 40 (n = 62)	1.488	0.662-3.424	0.338
<40 (n = 41)	1.000		
Underlying disease			
Hepatitis B/C-related cirrhosis (n = 21)	1.711	0.520-5.810	0.377
Cholestatic disease (n = 23)	1.000	0.303-3.301	1.000
Others (n = 36)	0.778	0.445-1.579	0.651
Hepatocellular carcinoma (n = 23)	1.000		
Child-Pugh classification			
C (n = 76)	1.823	0.729-4.893	0.203
A, B (n = 27)	1.000		
MELD score			
≥ 25 (n = 11)	2.985	0.839-12.096	0.091
< 25 (n = 92)	1.000		
ABO incompatibility			
incompatible (n = 23)	0.454	0.151-1.219	0.120
identical /compatible (n = 80)	1.000		
Graft type			
right graft (n = 61)	0.578	0.257-1.288	0.180
others (n = 42)	1.000		
GRWR			
≥ 0.8 (n = 68)	0.825	0.360-1.906	0.651
< 0.8 (n = 35)	1.000		
Preoperative ascites and/or pleural effusion			
Yes (n = 73)	4.865	1.795-15.662	0.001
No (n = 30)	1.000		
Preoperative SMI			
Low (n = 14)	1.618	0.512-5.119	0.406
Normal (n = 89)	1.000		
Preoperative IMAC			
High (n = 36)	1.126	0.489-2.568	0.778
Normal (n = 67)	1.000		
Preoperative VSR			
High (n = 23)	1.528	0.594-3.916	0.376
Normal (n = 80)	1.000		
Operation time (min)			
≥ 12h (n = 90)	0.742	0.228-2.478	0.619
< 12h (n = 13)	1.000		
Blood loss (ml)			
≥ 10000 (n = 25)	1.560	0.624-3.895	0.339
< 10000 (n = 78)	1.000		
Warm ischemic time (min)			
≥ 44 (n = 54)	1.506	0.682-3.374	0.312
<44 (n = 49)	1.000		
Cold ischemic time (min)			
≥ 107 (n = 52)	1.235	0.561-2.740	0.600
<107 (n = 51)	1.000		
WBC level at POD7 (10 ⁹ /L)			
≥ 10000 (n = 52)	1.016	0.459-2.251	0.968
<10000 (n = 50)	1.000		
Platelet level at POD7 (10 ⁹ /L)			
≥ 50 (n = 53)	0.686	0.307-1.516	0.352
<50 (n = 49)	1.000		
CRP level at POD7 (mg/dL)			
≥ 3.0 (n = 52)	0.733	0.329-1.619	0.442
<3.0 (n = 50)	1.000		

Table 3 - Univariate analysis of factors of high Alb administration (continuation)

Variable	Univariate		
	OR	95%CI	P
PT-INR level at POD7			
≥ 1.23 (n = 52)	2.333	0.187-0.957	0.039
<1.23 (n = 50)	1.000		
AST level at POD7 (U/L)			
≥ 40 (n = 52)	1.410	0.638-3.151	0.396
<40 (n = 50)	1.000		
ALT level at POD7 (U/L)			
≥ 70 (n = 48)	0.412	0.178-0.923	0.031
<70 (n = 54)	1.000		
T-Bil level at POD7 (mg/dL)			
≥ 5.0 (n = 52)	1.664	0.752-3.744	0.210
<5.0 (n = 50)	1.000		
Alb level at POD7 (g/dL)			
≥ 2.6 (n = 64)	0.368	0.158-0.837	0.017
<2.6 (n = 38)	1.000		
Cre level at POD7 (mg/dL)			
≥ 0.7 (n = 52)	2.777	0.124-6.453	0.013
<0.7 (n = 50)	1.000		
Maximum daily volume of ascites (ml)			
≥ 5000 (n = 45)	13.402	5.341-36.825	<0.001
< 5000 (n = 58)	1.000		
Postoperative date of the maximum daily volume of ascites (day)			
≥ 10 (n = 41)	5.431	2.341-13.199	<0.001
<10 (n = 62)	1.000		
Period of stay in the ICU (day)			
≥ 14 (n = 62)	3.793	1.601-9.660	0.002
<14 (n = 41)	1.000		
Incidence of re-operation			
Yes (n = 22)	1.7	0.653-4.441	0.274
No (n = 81)	1.000		
Incidence of rejection			
Yes (n = 53)	0.987	0.446-2.175	0.969
No (n = 50)	1.000		
Incidence of bacteremia			
Yes (n = 32)	2.219	0.951-5.260	0.065
No (n = 71)	1.000		
Incidence of CMV infection			
Yes (n = 61)	3.307	1.420-8.179	0.005
No (n = 42)	1.000		

Alb - albumin; ALT - alanine aminotransferase; AST - aspartate transaminase; BMI - body mass index; CMV - cytomegalovirus; Cre - creatinine; CRP - c reactive protein; GRWR - graft/recipient body weight ratio; ICU - intensive care unit; IMAC - intramuscular adipose tissue content; MELD - model for end-stage liver disease; PT-INR - prothrombin time-international normalized ratio; SMI - skeletal muscle mass index; T-Bil - total bilirubin; VFA - visceral fat area; VSR - visceral to subcutaneous adipose tissue area ratio; WBC - white blood cell

Table 4 - Multivariate analysis of factors of high Alb administration

Variable	Multivariate		
	OR	95%CI	P
Recipient Age			
≥ 50 (n = 65)	1.496	0.4435-154	0.512
< 50 (n = 38)	1.000		
MELD score			
≥ 25 (n = 11)	1.486	0.266-8.884	0.653
< 25 (n = 92)	1.000		
Preoperative ascites and/or pleural effusion			
Yes (n = 73)	5.720	1.432-28.684	0.013
No (n = 30)	1.000		
PT-INR level at POD7			
≥ 1.23 (n = 52)	3.463	1.148-11.659	0.027
<1.23 (n = 50)	1.000		

Table 4 - Multivariate analysis of factors of high Alb administration (continuation)

Variable	Multivariate		
	OR	95%CI	P
ALT level at POD7 (U/L)			
≥ 70 (n = 48)	0.900	0.277-2.973	0.861
<70 (n = 54)	1.000		
Alb level at POD7 (g/dL)			
≥ 2.6 (n = 64)	0.315	0.083-1.102	0.071
<2.6 (n = 38)	1.000		
Cre level at POD7 (mg/dL)			
≥ 0.7 (n = 52)	1.956	0.586-6.923	0.276
<0.7 (n = 50)	1.000		
Postoperative date of maximum daily volume of ascites (day)			
≥ 10 (n = 41)	5.663	1.752-20.441	0.003
<10 (n = 62)	1.000		
Period of stay in the ICU (day)			
≥ 14 (n = 62)	3.241	1.003-11.687	0.0495
<14 (n = 41)	1.000		
Incidence of bacteremia			
Yes (n = 32)	1.865	0.520-6.862	0.337
No (n = 71)	1.000		
Incidence of CMV infection			
Yes (n = 61)	1.766	0.529-6.030	0.353
No (n = 42)	1.000		

Alb - albumin; ALT - alanine aminotransferase; CMV - cytomegalovirus; Cre - creatinine; ICU - intensive care unit; MELD - model for end-stage liver disease; PT-INR - prothrombin time-international normalized ratio; WBC

healthy donor, providing a sign of delayed graft function (18). Even if the patient received a healthy liver, factors such as operation time, blood loss, CIT, WIT, MELD score, GRWR, and preoperative body composition might affect postoperative status. Moreover, a preoperatively impaired general condition of the patient undergoing LT would make it difficult to recover liver function early enough to maintain Alb concentration, especially in LDLT.

In the present study, preoperative ascites and/or pleural effusion was an independent predictor of massive Alb use after LT. Among the independent risk factors for massive Alb use, this was the only preoperative factor, and may thus provide a useful predictor in clinical settings. Some investigators have reported the significance of preoperative pleural effusion and/or ascites (19-21). We showed massive pleural effusion or ascites as an independent risk factor for poor post-transplant outcome or bacteremia (19,20). Laici et al. also investigated whether preoperative ascites, preoperative chronic obstructive pulmonary disease, malnutrition, encephalopathy, and early re-transplantation were significantly associated with post-LT infection (21). In the present study, the incidence of bacteremia was higher in the High group than in the Low group, although no significant difference was apparent. From the perspective of preventing postoperative massive Alb use and bacteremia, candidates for LT should optimally

register for DDLT and undergo LT before ascites and/or pleural effusion develop.

The costs for posttransplant Alb use need to be discussed. Continuous or intermittent drainage of ascites or pleural effusion after LT is sometimes necessary when patients have abdominal distension or dyspnea. As recommended by the European Association for the Study of the Liver (22), use of Alb with repeated large-volume paracentesis is thought to be necessary for volume replacement and improvement of graft function. However, persistent Alb administration is expensive. In Japan, overuse of Alb cannot be fully covered, although the national health insurance system covers some of the costs of Alb use. Considering the increasing constraints on medical finance, alternative methods for ascites drainage and Alb supplementation are needed. Cell-free and Concentrated Ascites Reinfusion Therapy (CART) has recently been performed for some cirrhotic patients with intractable massive ascites. CART offers some advantages over albumin administration (23). CART can reduce the need for Alb supplementation. This is because components of drainage fluid other than albumin, such as globulins and other factors, might effectively benefit the course of perioperative patients, and CART can prevent loss of such beneficial components (24). Moreover, preoperative use of CART could promote the activity of patients waiting for LT, helping to prevent progression to severe

sarcopenia. As CART is now a safe and effective method, we are going to introduce CART to reduce Alb use before and after LT in the near future.

In this study, surprisingly, the comparison of facets of Alb use such as duration of Alb administration, total dose of Alb administered, and maximum daily dose of Alb administered showed no significant differences between patients who underwent LDLT and DDLT. The finding that GRWR did not differ between High and Low groups in LDLT suggests that graft size itself might not affect the need for Alb supplementation. However, DDLT can offer large liver volume to the recipient, theoretically allowing earlier recovery of liver function and less ascites retention compared with LDLT. In the present study, median values for duration and total dose of Alb administered to the DDLT group seemed shorter and smaller than in the LDLT group. As the number of DDLTs performed is small, further investigations with larger sample sizes are needed to confirm the present findings.

There are some limitations to this retrospective study. First, the present investigation was a single-center study. Although our center is the largest LT center in Japan, a nationwide study is also needed to verify the findings from this single facility. Second, this study was retrospective in design. A prospective study will be needed to validate the findings of this study. Third, the number of DDLT patients remains relatively small.

CONCLUSION

In conclusion, preoperative ascites and/or pleural effusion, ICU stay >2 weeks, PT-INR ≥ 1.23 at POD 7, and maximum daily ascites volume occurring ≥ 10 days postoperatively were closely related to high postoperative use of Alb, and preoperative ascites and/or pleural effusion was a predictor of massive Alb use after LDLT. For these cases, CART might offer a new therapeutic alternative to reduce Alb use after LT.

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Conflict of interest statement

None of the authors have any conflicts of interest.

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