Single-Center Experience of Consecutive 522 Cases of Hepatic Artery Anastomosis in Living-Donor Liver Transplantation

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ABSTRACT

Objective. The aim of this study was to clarify risk factors and outcome of hepatic arterial complication after living-donor liver transplantations (LDLT).

Methods. From 2004 to 2010, 522 consecutive LDLTs were performed. We used univariate and multivariate analysis to identify the risk factor on a retrospective basis, and then analysis was performed for adult cases. Hepatic arterial complication included thrombosis, stenosis, and pseudoaneurysm.

Results. The arterial complication rate was 4.79% (25 cases). Each complication was 9 thromboses, 14 stenoses, and 2 pseudoaneurysms. Preoperative hemoglobin was significantly associated with thrombosis ($P = .021$), and arterial size with stenosis ($P = .037$). We could not find any association between arterial complications and biliary stricture. However, the outcome of biliary stricture treatment was associated with arterial stenosis. Of 9 cases with thrombosis, 7 patients underwent rearterialization and 2 were treated with low-molecular-weight heparin (LMWH). Of 14 stenosis cases, 2 patients were treated with the use of balloon dilatation, 10 patients were observed under LMWH, and 2 patients underwent retransplantation. In cases of pseudoaneurysm, 1 patient underwent revision of the aneurysm and the other was observed.

Conclusions. In our cohort, preoperative low hemoglobin level was a risk factor for thrombosis and artery size a risk factor for stenosis.

ALTHOUGH liver transplantation is the most effective treatment for acute and chronic end-stage liver disease, it is an operation with significant morbidity and mortality. Of all types of complications, hepatic arterial complication can be a serious outcome with a high mortality rate. Hepatic arterial complications that occur after living-donor liver transplantation (LDLT) are composed of hepatic arterial stenosis (HAS), thrombosis, and pseudoaneurysm. HAS occurred in 4%–11% of liver transplant recipients in an earlier series, although the incidence has likely been undervalued owing to a lack of monitoring [1,2]. HAS may predispose patients to anastomotic biliary strictures, which are typically thought to be due to local ischemic and mechanical factors [3,4]. Hepatic artery thrombosis (HAT) after LDLT is a serious complication with a high mortality rate. The incidence of HAT reported in the literature varies widely, ranging from 2.5% [5] to 9% [6]. HAT can be subdivided into early (occurring <1 month after liver transplantation) or late (occurring >1 month after liver transplantation) HAT [7–9]. HAT can present as fulminant hepatic necrosis and graft failure, sepsis, and liver abscesses or with worsening graft function related to ischemic bile duct injury leading to cholangitis, bile leak, and biliary strictures [10]. Pseudoaneurysms of the hepatic artery (HA) are rare complications of liver transplantation, which are characterized by a high mortality rate [11,12]. Most cases are mycotic, caused by local infection, and located in the anastomosis or stumps of ligated arterial side branches [11]. HA complications were traditionally thought to be a result solely of surgical factors. However, more

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recently, nonsurgical factors, such as a donor being of older age (≥65 years), recipient being in a hypercoagulable state, patients undergoing rejection episodes, and patients acquiring cytomegalovirus (CMV) infection, have been implicated [4].

Most published literature about risk factors of HA complications after orthotopic liver transplantation has focused on deceased-donor liver transplantation. The aim of the present study was to analyze donor-related, recipient-related, surgical, and postoperative factors to identify those risk factors associated with each HA complication after LDLT.

METHODS

From August 2004 to May 2010, 641 orthotopic liver transplantations were performed. We excluded 119 deceased-donor liver transplantations. There were 522 consecutive LDLTs that included pediatric and adult patients in our institution, all of which were performed at the Department of Surgery and Transplantation, University of Sungkyunkwan, Seoul, Korea. The analysis was performed in 522 LDLTs with a mean follow-up of 63.4 months. All adult cases used right hemiliver or extended right liver, and all pediatric cases used left hemiliver or left lateral liver.

Before transplantation, we investigated the donor's liver and other factors, including calculating the graft weight–recipient weight ratio (GRWR), graft volume–standard liver volume ratio (GV/SLV), remnant liver volume, HA anatomy, portal vein and hepatic vein anatomy, bile duct anatomy, donor age, amount of fatty liver, other medical history, blood chemistry, viral markers, etc. Our institution's criteria for living donors are GRWR >0.8, GV/SLV >40%, remnant liver volume >30%, age <50 years, amount of macrofatty change <30%, and minimal vascular and biliary anatomic variation.

The HA anastomosis was fashioned with the use of an interrupted 8-0 nylon suture under microscope between the graft right or left HA and the recipient right or left HA, common HA, and other available arteries. In adult cases, we used right or left HA (89.9%, 413/459), right gastroepiploic artery (2.1%, 10/459), common HA (7/459), middle HA (5/459), proper HA (4/459), right posterior or anterior HA (7/459), gastroduodenal artery (3/459), splenic artery (1/459), and cystic artery (1/459). There were 8 cases of double HA. In pediatric cases, we used left or right HA (57.1%, 36/63), common HA (8/63), proper HA (4/63), and right anterior HA, splenic artery, and middle HA in 1 case each. There were 8 cases of graft double HA in adults and 12 cases of graft double HA in pediatric recipients. All allografts were preserved with the use of a solution containing histidine, tryptophan, and ketoglutarate. There was no ABO-incompatible transplantation.

Immunosuppressive therapy consisted of cyclosporine or tacrolimus, corticosteroids, and mycophenolic acid. Duplex Doppler ultrasonography was performed on post-transplantation days 1, 3, and 5 or 7 and whenever indicated by clinical or biochemical findings. Computerized tomographic (CT) scan and DISIDA scan were routinely performed on post-transplantation day 14. In the presence of abnormal findings, HA angiography was performed.

We suspected HAS in the presence of a resistive index of <0.5 and prolonged systolic acceleration time at Doppler investigation [13]. Most cases of HAS were confirmed by means of CT angiography or HA angiography showing incomplete occlusion of arterial blood flow to the allograft due to the narrowing of the HA.

We defined HAT as the complete occlusion of arterial blood flow to the allograft, as confirmed by means of HA angiography.

Table 1. Mean Amounts of Transfusion Blood Products Until Postoperative Day 12 After Liver Transplantation

	Mean	SD	*P* Value
LDRBC			
No complication	3.69	4.483	.244
Hepatic artery thrombosis	8.00	9.165	
LDPC			
No complication	23.25	21.127	.711
Hepatic artery thrombosis	55.43	97.068	
FFP			
No complication	1.56	2.529	.149
Hepatic artery thrombosis	5.00	7.874	

Abbreviations: LDRBC, leukocyte-depleted red blood cells; LDPC, leukocyte-depleted platelet concentrate; FFP, fresh-frozen plasma.

Possible risk factors for HAT and HAS included etiology of recipient end-stage liver disease (related to malignancy or not), disease progress (chronic or acute), recipient sex and age, donor sex and age, recipient smoking and alcohol history, Model for End-Stage Liver Disease (MELD) score, cold ischemia time, operation time, type of arterial anastomosis (we defined graft right HA to donor right or left HA and graft left HA to donor left or right HA as typical and the other cases as atypical), number of graft arteries (single or double), GRWR, GV/SLV, artery size, preoperative and postoperative coagulation profile (including prothrombin time–international normalized ratio (PT-INR), antithrombin III, and fibrinogen), and complete blood cell count (hemoglobin and platelet count).

Statistical Analysis

Univariate analysis was performed for categoric variables with the use of Pearson χ^2 testing or Fisher exact testing to identify risk factors for HAT and HAS after LDLT. We analyzed continuous variables with the use of 2-tailed unpaired *t* test or Mann-Whitney test. On univariate analysis, a $P \leq .05$ was considered to be statistically significant. Variables with $P \leq .05$ in the univariate analysis were entered into a forward stepwise logistic regression analysis to estimate the odds ratio (OR) of each artery complication (dependent variables) and the presence or absence of potential prognostic factors (independent variables). The OR was defined as the exp[β-coefficient] with 95% confidence intervals (CIs). Kaplan-Meier estimates were used to calculate patient survival curves. Differences in survival curves were compared with the use of log-rank statistics.

RESULTS

A total of 24 complications (4.6%) that affected the HA were documented in 522 consecutive transplantations. HAT occurred in 9 cases (1.7%), HAS in 13 cases (2.5%), and HA pseudoaneurysm in 2 cases (0.4%). Most literature has classified HAT into 2 categories: early or late [5,7,10,14]. In our cohort, all HAT was early, with all cases occurring within 1 month after liver transplantation.

Hepatic Artery Thrombosis

The time interval between transplantation and the diagnosis of HAT ranged from 2 to 30 days (mean, 12.2 ± 7.9 d). Of these, 7 were treated with urgent surgical rearterialization (removal of thrombus and rearterialization with the use of the available artery: in 5 cases right gastroepiploic artery