Research Article

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Effects of hepatic artery type and number on bile complications in right lobe living donor liver transplant recipients: single center experience without hepatic artery thrombosis

Sağ lob canlı verici karaciğer nakli alıcılarında hepatik arter çeşidi ve sayısının safra komplikasyonları üzerine etkileri: hepatik arter trombozu olmaksızın tek merkez deneyimi

Ender Anılır, Feyza Sönmez Topçu, Alihan Oral, Emrah Şahin, Abuzer Dirican, Bülent Ünal

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Abstract

Purpose: Hepatic artery provides blood supply to the biliary tract of the graft, one of the causes of the biliary complications that may occur in the post-transplant period may be the problems of the recipient's hepatic artery. We examined the effect of post-transplant biliary complications according to the type and number of recipient hepatic arteries.

Materials and methods: One hundred eighty-five patients older than 18 years of age who underwent right lobe living donor liver transplant (LDLT) for end-stage liver cirrhosis were included in the study. The recipient's right hepatic artery (RHA), left hepatic artery (LHA), propria hepatic artery (PHA) and common hepatic artery (CHA), which were anastomosed to the graft artery and double hepatic artery anastomoses formed of the right and left hepatic arteries, were examined. Biliary complications were analyzed statistically in terms of single or double artery anastomosis and anastomoses with the right or the other hepatic arteries.

Results: There was no statistically significant difference between single and dual artery anastomoses in terms of bile duct stricture or leakage (p=0.767). No statistically significant difference was observed between RHA, LHA, PHA, CHA, and between single and dual arteries in the evaluation of artery selection between those with and without biliary tract complications (p=0.445)

Conclusion: Hepatic artery type selection and number of the recipient does not change the biliary tract complication.

Keywords: Hepatic artery, liver, transplantation, bile, complication.

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Öz

Amaç: Hepatik arter, grefte ait safra yollarının kanlanmasını sağlar. Nakil sonrası dönemde oluşabilecek safra komplikasyonlarının nedenlerinden biri de alıcının hepatik arterindeki sorunlar olabilir. Alıcı hepatik arterin tipine ve sayısına göre nakil sonrası safra komplikasyonlarının etkisini inceledik.

Gereç ve yöntem: Çalışmaya, son dönem karaciğer sirozu nedeniyle sağ lob canlı vericili karaciğer nakli (CVKN) uygulanan 18 yaş üstü 185 hasta dahil edildi. Alıcının greft arterine anastomoz yapılan sağ hepatik arter (SağHA), sol hepatik arter (SolHA), propria hepatik arter (PHA) ve kommon hepatik arter (KHA) ve sağ ve sol hepatik arterlerden oluşan çift hepatik arter anastomozları incelendi. Biliyer komplikasyonlar tek veya çift arter anastomozu ve sağ veya diğer hepatik arterlerle anastomoz yapılması açısından istatistiksel olarak analiz edildi.

Bulgular: Tek ve çift arter anastomozları arasında safra kanalı darlığı veya sızıntısı açısından istatistiksel olarak anlamlı fark yoktu (p=0,767). Safra yolu komplikasyonu olan ve olmayanlar arasında arter seçiminin değerlendirilmesinde SağHA, SolHA, PHA, KHA ile tek ve çift arterler arasında istatistiksel olarak anlamlı fark gözlenmedi (p=0,445).

Sonuç: Alıcılarda anastomozda kullanılan hepatik arter tipi ve sayısı sayısı safra yolu komplikasyon oranını değiştirmemektedir.

Ender Anılır, Asst. Prof. Biruni University Faculty of Medicine, Hepatopancreaticobiliary Surgery and Organ Transplantation Department, Istanbul, Türkiye, e-mail: dr.enderanilir@gmail.com (https://orcid.org/0000-0002-0024-1790) (Corresponding Author)

Feyza Sönmez Topçu, Asst. Prof. Istanbul Aydin University Medikalpark Florya Hospital, Radiology Department. Istanbul, Türkiye, e-mail: feyzasonmez@gmail.com (https://orcid.org/0000-0002-7450-2949)

Alihan Oral, Assoc. Prof. Biruni University, İnternal Medicine Clinic Department, Istanbul, Türkiye, e-mail: dr.alihanoral@gmail.com (https://orcid.org/0000-0003-1160-9340)

Emrah Şahin, M.D. Istanbul Aydin University Medikalpark Florya Hospital, Organ Transplantation Center, Istanbul, Türkiye, e-mail: dr.emrahsahin@gmail.com (https://orcid.org/0000-0001-5267-9068)

Abuzer Dirican, Prof. Istanbul Aydin University Medikalpark Florya Hospital, Organ Transplantation Center, Istanbul, Türkiye, e-mail: abuzerdirican@hotmail.com (https://orcid.org/0000-0002-8647-3268)

Bülent Ünal, Prof. Istanbul Aydin University Medikalpark Florya Hospital, Organ Transplantation Center, Istanbul, Türkiye, e-mail: bulentunal2005@yahoo.com.tr (https://orcid.org/0000-0003-2538-7961)

Anahtar kelimeler: Hepatik arter, karaciğer, transplantasyon, safra, komplikasyon.

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Introduction

Living donor liver transplantation (LDLT) stands as the most preferred surgical procedure for patients with end-stage liver cirrhosis and hepatocellular cancer who meet the criteria; often, right lobe donors are the preferred choice. Anatomical variations in the biliary tract and vessels in the donor graft, the condition of the recipient's portal vein, and the adequacy of arterial flow are factors that can affect the success of transplantation in terms of surgical technique. Among these factors, the hepatic artery (HA) plays a crucial role. The type, number, and diameter compatibility of the recipient's hepatic artery, as well as the presence of atherosclerotic diseases and intimal dissection that may occur in the artery, are significant considerations for ensuring proper graft vascularization [1, 2]. As the hepatic artery supplies blood to the biliary tract of the graft, complications in the recipient's hepatic artery can contribute to post-transplant biliary issues [3, 4]. In our study, we investigated the impact of post-transplant biliary complications based on the type and number of recipient hepatic arteries.

Materials and methods

A retrospective review was conducted on the liver transplantation (LT) database. The study encompassed 185 patients, aged 18 years and above, who underwent right lobe LDLT for end-stage liver cirrhosis between July 2021 and July 2023. Demographic data were calculated and stated in the study. Gender, age, MELD, Child-Pugh score, and etiology rates were analyzed. Whether the hepatic artery was left-or right-sided, and how many arteries there were analyzed. The recipient's right hepatic artery (RHA), left hepatic artery (LHA), propria hepatic artery (PHA) and common hepatic artery (CHA), which were anastomosed to the graft artery, were examined. Double hepatic artery anastomoses formed in the right and left hepatic arteries. Statistical analysis was conducted to assess biliary complications based on whether single or double artery anastomosis was performed and whether anastomoses involved the right hepatic artery or other hepatic arteries. The donor hepatic artery variations were classified according to Michel's classification, and bile variations were categorized following the classification [5, 6]. Those with single bile anastomosis and those with multiple biliary anastomosis were statistically analyzed separately for the right hepatic artery. In addition, which artery was used more in patients without biliary complications was statistically analyzed. As the study was designed retrospectively, patients were not provided with a written informed consent form. However, all procedures adhered to the ethical standards established by the committees overseeing human experimentation, both at the institutional and national levels, and were in the 1964 Declaration of Helsinki and its subsequent editions. The Human Experiments Ethics Committee granted approval for this study under the ethics committee.

Surgical technique

The anastomoses were performed by a single surgeon. Arterial anastomosis was done one by one with 8-0 polypropylene sutures. Biliary anastomoses were done one by one with 7-0 pds sutures, with the mucosal margin channel evolving from channel to channel or channel to plate. In addition, a 5 F-feeding catheter was placed on the biliary anastomosis proximally.

Postoperative hepatic artery evaluation

The hepatic artery flows were checked with Doppler ultrasonography (USG) in the first 3 days postoperatively. Results were confirmed by dynamic multiphase abdominal computed tomography (CT) in patients with suspected flow insufficiency. In addition, all patients underwent control thorax and dynamic multiphase abdominal CT on the 7th postoperative day.

Statistical analysis

Nominal and ordinal parameters were defined through frequency analysis, while scale parameters were characterized using means and standard deviations. Differences between

categorical parameters were assessed using the Chi-Square Test and Chi-Square Likelihood Tests. The normality of scale parameters was evaluated with the Kolmogorov-Smirnov test. The statistical software SPSS 17.0 for Windows was utilized with a 95% Confidence Interval.

Results

The average age was 54.4 years (ranging from 18 to 78), with a gender distribution of 44% female and 56% male. In terms of Child-Pugh classification, 25% of patients were classified as Child A, 38% as Child B, and the 37% as Child C. The mean MELD score for adult patients was 16.2 (Table 1).

Table 1. Demographic and etiology findings in LDLT recipients

n/%	LDLT Recipients (n:185)
Age (average)	54.4 (18-78)
Gender	
Famale	81 (44%)
Male	104 (56%)
Child Score	
Child A	46 (25%)
Child B	70 (38%)
Child C	69 (37%)
MELD Score	16.1
Anhepatic phase [Mean (minute)] (SD)/(min/max)	66.5 (±33.2)/(58-75.1)
Cold ischemia time [Mean (minute)] (SD)/(min/max)	72.2 (±20.4)/(65.4-92.3)
Operation time [Mean (minute)] (SD)/(min/max)	470 (±60.7)/(460-496)
G.R.W.R. [Mean (grams)] (SD)/(min./max.)	1.08 (±0.31)/(0.75-1.16)
ICU stay (Mean day) (SD)/(min./max.)	2.3 (±1.1)/(1.9-2.5)
Hospital stay (Mean day) (SD)/(min./max.)	15 (±7.1)/(14.7-17.2)
Etiology	
HBV	42 (22%)
HBV+HDV	10 (4%)
HCC	33 (18%)
NASH	29 (15%)
Autoimmune	12 (6%)
Alcohol	11 (5%)
Budd Chiari Syndrome	5 (2%)
Familial Cholestasis	2 (1%)
Primary Hyperoxaluria	2 (1%)
Hemachromatosis	2 (1%)
Wilson Disease	2 (1%)
HCV	2 (1%)
Cryptogenic	43 (23%)

LDLT: Living donor liver transplantation, HBV: Hepatitis B Virus, HCV: Hepatitis C virüs, HDV: Hepatitis D virüs, NASH: Nonalcoholicsteatohepatitis
SD: standart deviation

Upon examining etiological factors, the most prevalent factor among adults was Hepatitis B virus (HBV), accounting for 22%, followed by hepatocellular carcinoma (HCC) at 18%, and nonalcoholic-steatohepatitis (NASH) at 15%. The autoimmune etiology had a rate of 6%, while alcohol-induced cirrhosis and HBV+ Hepatitis D Virus (HDV) were at rates of 5% and 4%, respectively. Budd-Chiari syndrome had a 2% rate. Additional identified etiological factors comprised familial cholestasis, primary hyperoxaluria, hemochromatosis, Wilson's disease, and Hepatitis C Virus (HCV), each accounting for 1%. Cryptogenic cirrhosis was noted in 23% of the patients (Table 1).

The average cold ischemia time was 72 minutes, while the anhepatic phase duration averaged 66.5 minutes. The mean operative time was 470 minutes. Following surgery, patients stayed in the intensive care unit (ICU) for an average of 2.3 days, with a hospital stay averaging 15 days. (Table 1).

Graft artery anatomic variation was 60% type 1, 20% type 2, 16% type 3, and a total of 4% type 4, 5, 6 and 9. The anatomical variation of the graft bile duct on the donor preoperative dynamic multiphase CT scan and Magnetic Resonance Cholangio-Pancreatography (MRCP) imaging was type 1 (66%), type 2 (24%), and type 3 (10%).

In living-donor liver transplants, 96% (n:178) utilized living liver grafts with a single hepatic artery, while 4% (n:7) employed grafts with double hepatic artery branches. Among recipients, the anastomosis rate for the right hepatic artery was 88% (n:162), the rate for the left hepatic artery was 4% (n:8), the utilization rate for propria hepatic artery was 2% (n:4), and the utilization rate for the common hepatic artery was 2% (n:4). Double hepatic artery branches in the graft were anastomosed with the recipient's right and left hepatic artery. There was no statistically significant difference in biliary tract stricture or leakage between the patients in whom graft artery anastomosis was made to the recipient's RHA and those in which it was performed to the LHA and others (Table 2). Also, in the statistical analysis between RHA and all other artery anastomoses, no significant difference was observed in terms of bile duct complications (p>0.05). Again, no significant difference was observed between RHA, LHA, PHA, and CHA in terms of biliary complications (Table 3). There was no statistically significant difference between single and dual artery anastomoses in terms of bile duct stricture or leakage (p=0.767) (Table 2). No statistically significant difference was observed between RHA, LHA, PHA, CHA, and between single and dual arteries in the evaluation of artery selection between those with and without biliary tract complications (p=0.445) (Table 3). Furthermore, according to the Mitchell classification, 78% of the recipient arteries were Type 1, 19% were Type 2, and 3% were Type 3 (Table 4).

Table 2. Bile complication rates and statistical result according to recipient artery type and number

Recipient Artery (n/rate)	No Bile Complication	Bile Leakage	Bile Stricture	Total (n/rate)	*p value **X^2 value
RHA	130 (80.2%)	14 (8.6%)	18 (11.2%)	162 (100%)	
LHA	7 (87.5%)	-	1 (12.5%)	8 (100%)	
PHA	4 (100%)	-	-	4 (100%)	*0.767
CHA	2 (50%)	1 (25%)	1 (25%)	4 (100%)	**4.911
RHA+LHA (dual artery anastomosis)	6 (85.7%)	-	1 (14.3%)	7 (100%)	
Total	149 (81%)	15 (8%)	21 (11%)	185 (100%)	

RHA: Right Hepatic Artery, LHA: Left Hepatic Artery, PHA: Propria Hepatic Artery, CHA: Common Hepatic Artery, N: Number
*p value; Chi-Square Test, **X^2 value

Table 3. Statistical evaluation of whether there is a difference in the type and number of arteries between those with and without biliary complications

Recipient Artery (n/rate)	Bile Complication (-)	Bile Complication (+)	Total (n/rate)	*p value **X^2 value
RHA	130 (80.2%)	32 (19.8%)	162 (100%)	
LHA	7 (87.5%)	1 (25%)	8 (100%)	
PHA	4 (100%)	-	4 (100%)	*0.445 **3.723
CHA	2 (50%)	2 (50%)	4 (100%)	
RHA+LHA (dual artery anastomosis)	6 (85.7%)	1 (14.3%)	7 (100%)	

RHA: Right Hepatic Artery, LHA: Left Hepatic Artery, PHA: Propria Hepatic Artery, CHA: Common Hepatic Artery, N: Number
*p value; Chi-Square Test, **X^2 value

Table 4. Recipient artery types according to the Mitchell classification

(n/%)	Type 1	Type 2	Type 3	Type 4
RHA	145/ 78%	35/ 19%	5/ 3%	0/ 0%
LHA				
PHA				
CHA				

RHA: Right Hepatic Artery, LHA: Left Hepatic Artery, PHA: Propria Hepatic Artery, CHA: Common Hepatic Artery, N: Number

Discussion

During the post-transplant period, there may be complication rates of up to 25% in the hepatic artery, potentially resulting in graft loss of up to 50% in the recipient. Early or late ischemic bile duct problems may also arise due to flow insufficiency. These complications play a significant role in contributing to morbidity and mortality in the recipient [1, 2, 4, 7].

Among biliary complications after liver transplantation, strictures and leaks hold a crucial place [8-10]. While the liver can withstand ischemia due to its rich vascular network, the biliary system is highly vulnerable to ischemia, primarily relying on the hepatic artery for its blood supply. Insufficiency in hepatic artery flow, leading to ischemia, plays a significant role at both the anastomosis level and in the etiology of hilar or intrahepatic bile duct strictures [2, 3, 7, 11].

Hepatic artery thrombosis significantly increases graft loss and early postoperative mortality; however, non-thrombotic hepatic artery flow insufficiency may necessitate long-term interventional and surgical interventions due to bile complications in recipients [12]. Furthermore, the risk of early hepatic thrombosis increases with the selection of the recipient artery towards its distal portion and an increase in artery length [13].

Despite the seemingly better outcomes of using the right hepatic artery for hepatic artery reconstruction in right lobe LDLT [14], the impact of different artery selections on biliary tract complications has been explored in various studies. It has been noted that the biliary stricture rate is higher in recipients where the right hepatic artery is used compared to the left artery, and this rate decreases in propria hepatic artery anastomoses [14-16]. While the use of the left hepatic artery correlates with a decrease in the biliary stricture rate, it is crucial not to overlook the findings indicating that the overall biliary complication rates remain unchanged regardless of whether the right or left hepatic artery is utilized [17]. Nevertheless, studies have also shown no significant difference in

terms of biliary complications between patients who underwent dual artery anastomosis (for example, a preference for both the right and left hepatic arteries) and those who underwent single artery anastomosis [18, 19]. In our study, no significant difference was observed between right, left, propria, and common hepatic artery choices in terms of bile duct complications. Similarly, no difference was observed between single and dual artery anastomoses in altering the biliary tract complication rates. There was no significant difference in hepatic artery selection between patients with strictures and leaks in the bile ducts and those without complications.

The study's limitations include the lack of information on recipient body mass index (BMI) values, chronic comorbidities, and preoperative nutritional status.

While the recipient's selection of the hepatic artery type does not alter the biliary tract complication rates, factors such as sufficient blood flow, the length of the chosen artery, the absence of intimal damage, and the absence of atherosclerosis should not be overlooked.

Conflict of interest: No conflict of interest was declared by the authors.

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Authors' contributions to the article

E.A. constructed the main idea and hypothesis of the study. A.O., F.S.T. and E.S. developed the theory and arranged/edited the material and method section. E.A. and E.S. have done the evaluation of the data in the Results section. Discussion section of the article written by E.A.

B.U. and A.D. reviewed, corrected and approved. In addition, all authors discussed the entire study and approved the final version.