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Placement of an Aortohepatic Conduit as an Alternative to Standard Arterial Anastomosis in Liver Transplantation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCE 1 **Dong-Hwan Jung**
BCDE 2 **Cheon-Soo Park**
BCDE 1 **Tae-Yong Ha**
CDF 1 **Gi-Won Song**
CDF 1 **Gil-Chun Park**
ACDEG 1 **Yong-Pil Cho**
ABCDE 1 **Sung-Gyu Lee**

1 Department of Surgery, University of Ulsan College of Medicine and Asan Medical Center, Seoul, South Korea
2 Department of Surgery, Gangneung Asan Hospital, University of Ulsan College of Medicine, Gangneung, South Korea

Corresponding Author: Yong-Pil Cho, e-mail: ypcho@amc.seoul.kr
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Background: The aim of this study was to assess the impact of placement of an aortohepatic conduit on graft and patient survival after liver transplantation (LT) in selected patients with an inadequate recipient hepatic artery (HA) for a standard arterial anastomosis.

Material/Methods: Of 331 patients who underwent deceased donor LT, 25 (7.6%) who received placement of an aortohepatic conduit at the time of transplantation were included. Clinical characteristics and outcomes, including postoperative complications, conduit patency, and graft and patient survival rates, were analyzed.

Results: All 25 patients included in this study presented a high preoperative Model for End-stage Liver Disease score (25.4±8.6; range, 6–42) and high rates of retransplantation (n=11, 44%) or previous abdominal – pelvic surgery (n=5, 20%). The observed postoperative vascular complications were portal vein thrombosis in 3 cases (12%) and anastomosis-site bleeding of the aortohepatic conduit in 1 case (4%); there was no HA thrombosis or stenosis in our analysis. With a median follow-up of 37 months (range, 0–69 months), all aortohepatic conduits were patent, and the graft and patient survival rates were 84% and 68%, respectively. The causes of death were graft failure (n=4), pneumonia (n=3), and cerebrovascular accidents (n=1).

Conclusions: Our results indicate that placement of an aortohepatic conduit is a feasible alternative to a standard arterial anastomosis in selected patients whose HA and surrounding potential inflow arteries are not suitable for standard arterial anastomosis.

MeSH Keywords: **Graft Survival • Liver Diseases • Liver Transplantation**

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Background

Although there is considerable controversy about the assessment of the safety and indications of aortohepatic conduits, placement of an aortohepatic conduit is an important alternative in liver transplantation (LT) in an era when increasingly older patients are registered in LT waiting lists and when salvage transplantations or re-transplantations are more commonly performed in selected patients [1–8]. This technique has been used frequently in complex cases, particularly for recipients at high risk for arterial thrombosis, those with severe atherosclerotic disease (which is more common in older recipients), those with previous liver or biliary tract operations, or those with re-transplantations, when a standard arterial anastomosis between the hepatic artery (HA) of the graft and that of the recipient fails to provide sufficient inflow [1,2]. In the event of inadequate inflow in the recipient HA, an arterial allograft, recovered from the same donor and then interposed between the recipient aorta and the grafted HA, is usually used [3,4,9].

Although placement of an aortohepatic conduit undoubtedly provides a lifesaving solution for many recipients in LT, some authors suggested that use of this technique should be strictly limited because of the high complication rates and impaired graft survival [2–4,10]. The aim of the present study was to assess the impact of placement of an aortohepatic conduit on graft and patient survival after LT in selected patients with an inadequate recipient HA for a standard arterial anastomosis.

Material and Methods

Our prospectively-collected institutional LT database was searched to identify adult LT recipients with an inadequate HA for a standard arterial anastomosis, who underwent deceased donor LT (DDLT) with placement of an aortohepatic conduit because of end-stage liver failure, between May 2011 and June 2016. Pediatric recipients (aged <18 years) and recipients who received living donor LT (LDLT) were excluded. The study protocol was approved by our Institutional Review Board, which waived the need for informed consent.

DDLT was performed with standard techniques [11]. The type of arterial revascularization of the liver allograft was determined at the time of the transplantation based on the adequacy and availability of the recipient HA. When the standard arterial anastomosis failed to establish sufficient arterial inflow, aortohepatic conduits were placed between the infrarenal aorta and hepatic hilum via the transverse mesocolon through the retrogastric plane. In all cases in this study, placement of an aortohepatic conduit was performed with the donor aorto-iliac arterial segment obtained during liver procurement and preserved in preservation solution. Proximal anastomosis between the aorto-iliac arterial segment and the aorta was created by using 5-0 running Prolene. To promote wider vessel ends at the distal anastomosis between the conduit and the donor HA (or celiac trunk), we incised the vessel end of the donor HA longitudinally and used 6-0 running Prolene to create the distal anastomosis. This technique also reduced donor HA–conduit size discrepancy. A schematic diagram of the surgical procedure is provided in Figure 1.

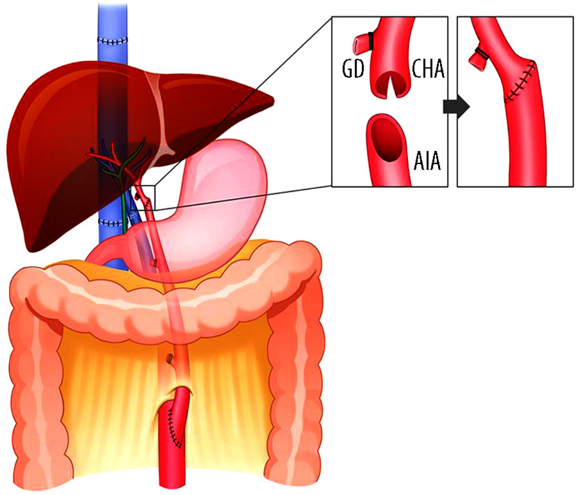

Figure 1. Schematic diagram of the surgical procedure. AIA – deceased donor aorto-iliac arterial segment; CHA – common hepatic artery; GD – gastroduodenal artery.

The patency of arterial anastomosis was assessed serially with Doppler ultrasonography (DUS). DUS was performed daily in the first week and weekly during the hospital stay. After discharge, DUS was indicated whenever patients showed elevated liver enzyme levels or signs of hepatic dysfunction. If there was a clinical suspicion of compromised arterial flow, computed tomography (CT) or hepatic angiography was performed to further delineate the arterial inflow to the liver, according to each patient's condition. The recipients were treated with conventional immunosuppressive therapy after transplantation [12]. Prostaglandin E1 and antithrombin III were administered immediately after transplantation and continued for 2 weeks and 10 days, respectively. Seven days after transplantation, low-dose acetylsalicylic acid (100 mg once daily) was prophylactically prescribed for at least 3 months in all recipients with a platelet count of >50 000/µL and with no signs of coagulopathy.

Clinical characteristics and outcomes, including postoperative complications, conduit patency, and graft and patient survival rates, were analyzed. A diagnosis of HA thrombosis was determined according to the absence of HA enhancement on CT or hepatic angiography, or based on the identification of a complete occlusion of the HA during surgical exploration [2]. HA stenosis was defined as ≥50% luminal narrowing on CT or hepatic angiography. Biliary complications included anastomotic leakage or stricture, ischemic cholangiopathy, and other complications. Graft loss or patient death within 1 month after transplantation was defined as early loss, and any loss thereafter was defined as late.

Categorical variables are reported as frequencies or percentages, and continuous variables as means and standard deviations.

Results

A total of 1928 adult LTs (1597 LDLTs and 331 DDLTs; 1852 primary LTs and 76 repeat LTs) were performed at our institution between May 2011 and June 2016. The 5-year overall patient survival rates were 86.6% in LDLTs and 74.1% in DDLTs. Of the 331 patients with DDLT, 25 (7.6%) (including 1 case of salvage transplantation) underwent placement of an aortohepatic conduit, whereas a standard arterial anastomosis was performed in the overwhelming majority of recipients. The 25 recipients with placement of an aortohepatic conduit were included in this analysis.

The baseline characteristics of the 25 recipients are presented in Table 1. These patients presented a high preoperative Model for End-stage Liver Disease (MELD) score (25.4±8.6; range, 6–42) and high rates of re-transplantation or previous abdominal–pelvic surgery. Sixteen patients (64%) had undergone previous abdominal–pelvic surgery: LT in 11, partial hepatectomy in 1, pancreatoduodenectomy in 2, and gynecologic operation in 2 patients. The indications for LT were re-transplantation (n=11, 44%), hepatitis B cirrhosis without hepatocellular carcinoma (n=5, 20%), hepatitis B cirrhosis with hepatocellular carcinoma (n=4, 16%), and others (n=5, 20%). Among the patients who received retransplantation, there were 9 cases of second LT and 1 of each case of third and fourth LT; the previous LTs were performed using a standard arterial anastomosis in all cases. The indications for placement of an aortohepatic conduit were: poor arterial perfusion, which was determined at the time of transplantation based on the loss or severe attenuation of pulsatile blood flow under palpation of the recipient HAs or on a dampened flow and tardus parvus waveform of intra-HAs after reconstruction in intraoperative DUS (n=18, 72%); a size discrepancy because of small recipient HA (n=3, 12%); intimal dissection in the recipient HA (n=2, 8%); and difficulty in exposing recipient arteries because of severe adhesions or extensive varices in the hepatic hilum (n=2, 8%).

With a median follow-up of 37 months (range, 0–69 months), the observed postoperative vascular complications were portal vein thrombosis treated with stenting in 3 cases (12%) and anastomosis-site bleeding of the aortohepatic conduit treated with surgical revision in 1 case (4%); there was no early or late HA thrombosis or stenosis in our analysis. No postoperative biliary complications were observed. During the follow-up period, all aortohepatic conduits were patent, and the graft and patient survival rates were 84% and 68%, respectively (Table 2). Except in the 4 cases of mortality associated with the graft failure (16%), the transplanted liver graft function was maintained in the other 4 mortality cases, in which causes of death were pneumonia (n=3, 12%) and cerebrovascular accidents (n=1, 4%).

Table 1. Clinical characteristics of the study population.

	Patients (n=25)	
Mean age (years)	51.5±10.3	(28–69)
Male sex	14	(56)
Body mass index (kg/m^2)	20.9±2.4	(17.0–26.3)
Previous abdominal–pelvic surgery	16	(64)
Indications for liver transplantation		
Retransplantation	11	(44)
HBV-LC without HCC	5	(20)
HBV-LC with HCC*	4	(16)
Others	5	(20)
MELD score	25.4±8.6	(6–42)
Preoperative hospital days	30.8±24.2	(0–95)
Postoperative hospital days	59.3±43.0	(2–165)
Operative findings		
Operative time (min)	703.2±142.8	(451–1058)
RBC transfusion (packs)	27.6±19.3	(6–75)
FFP transfusion (packs)	25.5±20.3	(6–90)
Cold ischemia time (min)	248.7±84.9	(79–423)
Warm ischemia time (min)	47.9±14.3	(25–90)

Continuous data are expressed as means ± standard deviations (range) and categorical data as numbers (%).
HBV-LC – hepatitis B cirrhosis; HCC – hepatocellular carcinoma; MELD – Model for End-stage Liver Disease; RBC – red blood cells; FFP – fresh frozen plasma. * Included three recipients with previous chemoembolization procedures.

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Table 2. Posttransplantation clinical outcomes of the study population.

	Early (≤1 month after LT)	Total*
Conduit patency	25 (100)	25 (100)
Graft survival	23 (92)	21 (84)
Patient survival	21 (84)	17 (68)
Cause of death		
Graft failure	2 (8)	4 (16)
Pneumonia, sepsis	2 (8)	3 (12)
CVA	0	1 (4)

Values are presented as numbers of patients (%). LT – liver transplantation; CVA – cerebrovascular accidents. * During a median follow-up of 37 months (range, 0–69 months).

Discussion

Although usually well-tolerated by native livers, a compromised HA blood flow confers life-threatening risks in the newly-implanted liver graft [1,2,6,13]. Therefore, reconstruction of the HA is one of the principal technical challenges in LT, and successful graft and patient survival depends on robust, uninterrupted arterial flow into the transplanted liver graft. Because oxygen is delivered to the graft biliary ductal system almost solely through the HA, and because the recipient's collaterals to the liver are divided during recipient hepatectomy, the technical aspects of arterial reconstruction (inflow, anastomosis, and outflow) are critical issues [10,14–17]. Complications related to the HA are a major source of recipient morbidity and graft loss and can lead to recipient mortality [10,14–16]. Maintenance of HA patency and optimal hepatic blood flow requires satisfactory arterial inflow in the recipient, a properly oriented anastomosis with appropriate intima-to-intima approximation, and relatively low-resistance outflow through a healthy liver graft. Achieving these goals requires thorough preparation before transplantation by performing imaging studies to detect anomalies of the HA, effective donor–recipient size matching, meticulous surgical technique at organ procurement and during transplantation, and minimization of the cold ischemia time to limit ischemia–reperfusion injury [2,18]. However, when the arterial flow to the liver graft is limited by poor recipient arterial inflow in more complex cases, the alternative to a standard anastomosis between the HA of the graft and that of the recipient is required to provide sufficient inflow.

Unlike the veins, the graft HA is never reused. There are several reports of graft HA necrosis leading to arterial thrombosis or rupture [19]. Because one of the most common indications for re-transplantation is HA thrombosis, the supraceliac or infrarenal aorta may be needed as the source of arterial inflow in cases of retransplantation [6]. Although the donor celiac trunk and associated aorta, giving rise to the donor HA, is often of sufficient length to reach the supraceliac aorta, it is unlikely to be long enough to reach the infrarenal aorta. Hence, procurement of the donor aorto-iliac arterial segment for vascular grafts and more liberal use of aortohepatic conduits are especially important in cases of re-transplantation or poor recipient arterial inflow. Although both supraceliac and infrarenal approaches are considered to provide satisfactory results [6,13,20,21], the infrarenal bypass is the most popular approach once a standard arterial anastomosis fails to provide sufficient arterial blood supply in transplanted liver graft, due to an increased incidence of HA thrombosis after supraceliac reconstruction [22]. Reconstruction with aortohepatic conduits through the infrarenal approach has been shown to produce excellent short- and long-term results [1]. In the present study, all included recipients underwent DDLT with the placement of an aortohepatic conduit through the infrarenal approach.

MELD score is an important predictor of early mortality after LT [5], and use of an arterial conduit is associated with more vascular complications [3]. Although a conduit *per se* does not influence graft survival, the inferior outcome may reflect the complex situation of the worse preoperative condition of the transplant patients needing a non-standard arterial anastomosis [3]. While patients with worse preoperative condition (high MELD score and high rates of retransplantation or previous abdominal–pelvic surgery) were included in the analysis, and a longer postoperative hospital stay and a larger amount of transfusion were noted compared with other previous studies [1,2,6], our results indicate that placement of an aortohepatic conduit is a feasible alternative to a standard arterial anastomosis in strictly selected patients whose HA and the surrounding potential inflow arteries are not suitable for standard arterial anastomosis. In the present study, no HA thrombosis or stenosis was observed during the follow-up period. Thrombosis of the HA and the aortohepatic conduit remains the major problem [23–25]. We believe that a meticulous surgical technique and aggressive surveillance are crucial in preventing this complication, in addition to prophylactic therapies such as acetylsalicylic acid and other post-transplantation medications [1].

In adult primary LT, placement of an aortohepatic conduit was reported to be associated with an increased risk for graft loss up to 5 years after transplantation, due to HA thrombosis and infection/sepsis [2]. Therefore, this technique should be strictly limited to recipients whose inflow arteries are not suitable for a standard arterial anastomosis despite exhaustive measures to isolate the vessels. In addition to pretransplantation

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imaging studies on the recipient, donor–recipient size matching and delicate and meticulous surgical maneuvers at organ procurement and during transplantation are paramount in preserving normal arterial anatomy and facilitating a standard arterial anastomosis [10].

The present study has certain limitations. First, it was a retrospective analysis of a prospectively-maintained database, which did not allow for direct, randomized comparisons of the clinical outcomes with a standard arterial anastomosis. The decision to perform the placement of an aortohepatic conduit was based only on the intraoperative status determined by the operating surgeons. Hence, this study may have been subject to selection and information biases. Second, our current findings were obtained at a single center, leading to a small sample size that limits the overall relevance of our results. Finally, the follow-up duration may be insufficient to prove the longevity of placement of an aortohepatic conduit in LT.

Conclusions

Despite the aforementioned potential limitations, our study clearly shows that the placement of an aortohepatic conduit provides a lifesaving solution for selected recipients with inadequate inflow arteries during LT. Excellent long-term graft and patient survival rates can be obtained with meticulous surgical technique and aggressive surveillance.

Conflicts of interest

None.

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