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ORIGINAL ARTICLE

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Microvascular hepatic artery anastomosis in pediatric segmental liver transplantation: microscope vs loupe

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Abstract Use of operative microscopy (OM) has dramatically reduced the incidence of hepatic artery thrombosis (HAT) in children undergoing segmental liver transplantation. We used OM (12–16×) in our early experience. We changed to high power loupe magnification (6×) after 14 cases. We examined our experience with microvascular hepatic artery reconstruction in 28 consecutive children (<18 years) who underwent living donor (LDLT) or split liver transplantation (SLT). Reconstructions were done with interrupted, end-to-end anastomoses with 8–0 polypropylene using microvascular techniques. Group 1 consisted of 14 children who underwent LDLT employing OM for the hepatic artery anastomosis. Group 2 consisted of the subsequent 14 children (11 LDLT, 3 SLT) in whom 6× loupe optics were used for the arterial anastomosis. Grafts included 25 left lateral segments, 2 left lobes, and 1 right lobe. Recipients' median age was 1.0 years (range 3 months to 17 years). The mean follow-up time was 27.1 months. There were no cases of HAT. Variables of age, sex, graft type, number of Doppler ultrasound exams (DUS), and biliary complications were similar between groups. Microvascular hepatic artery reconstruction in children with 6× loupe magnification can yield results as good as operative microscopy.

Keywords Pediatric transplant · Liver transplantation · Segmental graft · Hepatic artery · Microvascular anastomosis · Technical complication

Introduction

In the 1980s liver transplantation emerged as the only effective treatment for end-stage liver disease (ESLD). As surgical techniques and immunosuppression improved, the waiting list for transplantation with scarce cadaver organs grew. The discrepancy between the number of candidates and appropriate donor organs was especially pronounced in children. During this era, as many as 25–50% of children who were candidates for liver transplantation (LTx) were dying [1], due to the high incidence of pediatric liver disease coupled with a paucity of pediatric organ donors. This crisis gave rise to the development of reduced size (RLT), split (SLT), and living donor liver transplantation (LDLT).

Arterial reconstruction is the hardest and most important facet of segmental transplantation in children. Use of the operating microscope was initiated due to high arterial thrombosis rates in early series [2]. Currently, most groups use operative microscopy (OM) to perform arterial reconstruction. Our center used OM (12–16×) in our early experience but have recently modified our technique. Our center now uses high-power loupe magnification (6×) with microvascular instruments instead of OM. This change was prompted by our increasing experience with high power loupes for adult LDLT.

Patients and methods

Twenty-eight cases of segmental transplantation (LDLT or SLT) were performed in children under 18 years in our institution between January 1998 and October 2001. We reviewed our experience with microvascular hepatic artery reconstruction in these children. Patients were divided into two groups. Group 1 consisted of 14 children who underwent LDLT employing OM (model OPMI 6-SFC, Zeiss, Germany) for the hepatic artery anastomosis. Our anastomotic technique using OM has been well described by other authors [3, 4]. Group 2 consisted of the next 14 children transplanted (11 LDLT, 3 SLT) in whom 6× loupe optics were used for the arterial anastomosis. All anastomoses in both groups were completed by a single transplant surgeon. In all cases patency of the arterial anastomosis was verified intraoperatively with pulse Doppler examination.

Our current anastomotic technique is as follows: The recipient right and left hepatic arteries are dissected high in the porta hepatis to maximize arterial length and the flexibility of reconstruction. The arteries are ligated with vascular clips and divided. This dissection is then carried proximally to the bifurcation of the proper hepatic artery and onto the common hepatic artery. The common hepatic artery is dissected and the gastroduodenal artery ligated and divided if necessary to facilitate mobilization. The donor hepatic artery is then examined and the appropriate sized-matched vessel is used for reconstruction (Fig. 1). The anastomosis is performed with interrupted 8–0 polypropylene sutures using high power loupe magnification (6.0×; Designs for Vision, Inc., Ronkonkoma, N.Y.) Prior to performance of the anastomosis, the arteries are flushed with heparinized saline, and fine vascular clamps are used to obtain proximal and distal control. Two sutures are then placed in the corners, left untied, and secured with tag clamps (Fig. 2). Additional sutures are placed beginning at the middle of the artery, and most commonly two or three sutures are placed on each side of the middle suture. The anterior wall sutures are placed first, left untied, and secured with tag clamps to prevent entanglement with previously placed sutures. After all of the anterior wall sutures are placed, they are then tied by hand, with the exception of the corners. The arteries are then rotated 180° and the posterior wall of sutures are placed in similar fashion and tied after all sutures are placed. The vascular clamps are then removed to reestablish flow through the hepatic artery (Fig. 3).

All patients underwent Doppler ultrasound (DUS) on POD 1 to evaluate patency of vascular anastomoses.

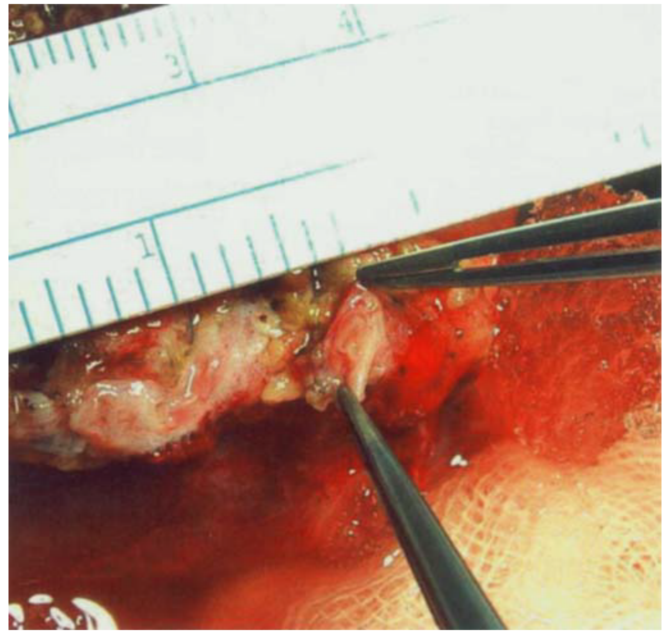

Fig. 1 Left hepatic artery of a left lateral segment graft. The vessel caliber is approximately 2 mm

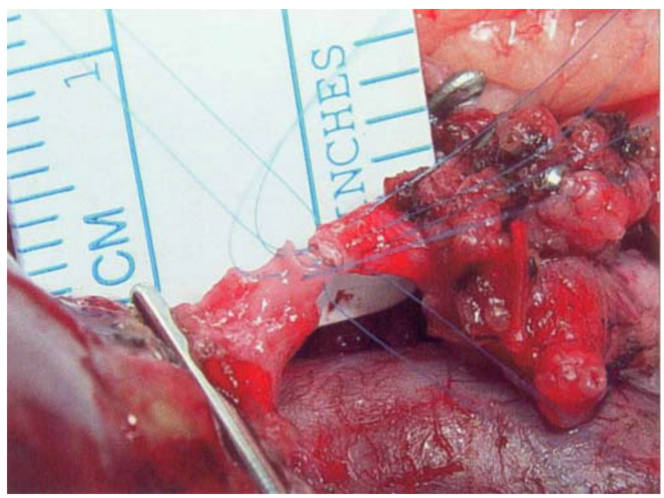

Fig. 2 Setup of the end-to-end interrupted arterial anastomosis using 6.0X loupes. The recipient's left hepatic artery was used for inflow

Subsequent DUS were obtained as clinically indicated. All children received appropriate weight-based doses of aspirin by mouth starting on POD 1 and continued for 1 month.

Data were collected from charts, operative reports, and radiology reports. Statistical analysis was done with contingency tables and Student's *t*-test using Stat View 5.0.1. (SAS, Cary, N.C.) where appropriate, with $p < 0.05$ considered significant.

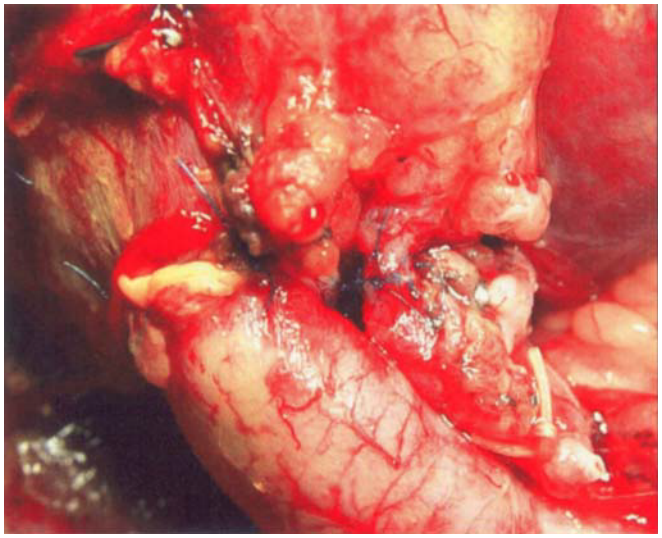

Fig. 3 Completed arterial and portal anastomoses

Results

Age, gender, graft type, preoperative prothrombin time (PT), operative time and total number of DUS were similar between groups. Grafts included 25 left lateral segments, 2 left lobes, and 1 right lobe. The median age of the cohort was 1.0 year (range 3 months to 17 years). The mean age was slightly higher in group 2, but this did not reach significance (Table 1). All patients received ABO compatible grafts and in no case was a vascular conduit required for the anastomosis.

There was no HAT in our series. The mean number of DUS was 3.1 ± 1.9. There was a trend toward increased operative time in the Loupe group, although the difference did not reach statistical significance. Estimated blood loss (EBL) and packed red blood cell (PRBC) transfusions were also higher in this group, although these differences did not achieve significance. All patients except one had a negative DUS on POD 1. During exploration, this patient was found to have a patent artery. Several patients had "decreased diastolic flow" on DUS. In each of these patients, repeat DUS 24–48 h later showed patent arteries with normal direction flow. Biliary complications were similar in both groups

At a mean follow-up of 27.1 months, actual patient and graft survival were 92.8 and 89.3%, respectively.

Discussion

Early experience in pediatric LDLT and SLT was plagued by vascular complications. Rates of arterial thrombosis were as high as 28% [5]. Tanaka's group reported excellent results after initiating the use of OM [2]. They reduced their HAT rate from 28.6 to 5.4%. Many other centers switched to OM soon after, reducing HAT rates from 20 to 0% in some reports [3, 6, 7]. Development of microvascular techniques instilled the confidence to perform multiple anastomoses without the use of conduit and to abandon routine preoperative donor angiography in LDLT [2, 5].

The initial reports described use of 5–10× magnification with OM. [6]. As experience in segmental transplantation grew and high power loupe optics (4.5–6.0×) became available, some surgeons became comfortable using microsurgical techniques without the microscope, especially for right lobe LDLT. In our program we extended these techniques to our pediatric LDLTs as well. Thus far, we have enjoyed excellent success, with no episodes of HAT or stenosis in our pediatric cases. Our findings, however, are somewhat limited by our small numbers.

In many institutions, consulting microsurgeons perform the arterial reconstruction. We believe experienced transplant surgeons employing the techniques we describe should obtain excellent results. As with all demanding procedures, there is a learning curve. Close mentorship is essential in successful arterial reconstruc-

Table 1 Comparison of microscope and loupe groups. *US* ultrasound, *LLS* left lateral segment, *LL* left lobe, *RL* right lobe, *SLT* split liver transplant, *EBL* estimated blood loss, *PT* prothrombin time, *HAT* hepatic artery thrombosis, *NS* not significant

Characteristic	Microscope (group 1)	Loupe (6×; group 2)	*p*-value
Patients (*n*)	14	14	NS
Age (years)	1.66 ± 1.73 (range 4 months to 6.3 years)	4.35 ± 6.38 (range 5 months to 17 years)	NS
Type of graft	14 LLS	11 LLS, 2 LL, 1RL	NS
Donor	Mother 11, father 2, friend 1	Mother 6, father 4, SLT 4	–
Preop PT (s)	14.3 ± 2.9 (range 12.3–24.2)	15.7 ± 3.2 (range 12.5–22.6)	NS
Operative time (min)	476.2 ± 40.3 (range 405–558)	532.1 ± 100.0 (range 300–720)	NS (0.07)
EBL (cc)	380.8 ± 400.8 (range 100–1500)	672.7 ± 555.1 (range 100–2000)	NS
Doppler US (*n*)	3.2 ± 1.9 (range 1–7)	3.0 ± 2.0 (range 1–6)	NS
Patient survival	85.7%	92.8%	NS
HAT (*n*)	0	0	NS

tion of partial grafts, regardless of the optical enhancement used.

The use of loupes is less cumbersome than OM and easier to teach to trainees. We believe that without OM, it is easier to compensate for diaphragmatic movement due to respiratory variations. Surprisingly, we saw a trend toward longer total operative times and higher EBL and PRBC transfusion in the Loupe group. The significance of these findings is unclear but may be secondary to more complex cases performed as our program expanded. Unfortunately, anastomotic times were not available. These are more pertinent to the comparison of the two techniques.

Recently, there have been several reviews of the microsurgical experience in LDLT, with HAT rates between 0 and 4% in series larger than ours [4, 7, 8, 9]. The ramifications of technical errors are enormous in pediatric segmental transplantation; thus, it is unlikely that there will be a rush to abandon use of the microscope in the near future. Our report does demonstrate, however, that in experienced hands, results of arterial reconstruction using high-power loupe optics can be equivalent to operative microscopy.

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