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Delayed primary closure of the abdominal wall after cadaveric and living related donor liver graft transplantation in children: a safe and useful technique

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Abstract Due to the shortage of size-matched liver donors, relatively oversized liver grafts (even after ex situ volume reduction) are frequently used for liver transplantation in children. This was recently observed when livers from large, living related donors were procured for transplantation in very small recipients. Given that abdominal hyperpressure can compromise vascular flow in the new graft, primary closure of the abdomen was delayed by temporary Silastic prosthetic closure in selected cases. The new technique was original in that the skin was closed, avoiding fluid loss and reducing the risk of infections reported with other techniques, and in that reoperation allowed for a delayed, but primary-type, closure (fascia and skin) that resulted in an esthetically correct aspect. Over a period of 7 years, 330 pediatric liver transplantations were performed, and delayed prosthetic closure was achieved successfully and safely in 47 cases. The present report outlines this clinical experience.

Key words Pediatric liver transplantation, abdominal wall, prosthesis · Abdominal wall, pediatric liver transplantation, prosthesis · Prosthesis, pediatric liver transplantation, abdominal wall

Introduction

Primary abdominal wall closure can sometimes be difficult after liver transplantation, most often in cases involving an oversized liver graft with or without liver edema and, less frequently, when there is edema or distension of the intestine [14, 20, 21, 23, 25]. Since 1989, when the fascial tension to close the abdomen after liver transplantation has been excessive, we have chosen to use a temporary Silastic prosthetic closure (SP-C). In comparison with other reported techniques [10, 14, 20, 22, 23, 27], ours is original in that the skin is closed, thus avoiding the risk of fluid loss or of infection. In addition, the prosthetic material can be completely removed within the first few postoperative weeks.

The present report outlines our experience with this original technique, comparing immediate closure (Dir-C) with temporary SP-C of the abdomen in a series of 330 pediatric liver transplantations. This delayed, but primary-type, abdominal closure has proved safe and has benefited mostly very small infants who would probably otherwise have had to wait much longer before receiving a better size-matched liver graft.

Materials and methods

Between January 1989 and January 1996, 330 liver transplantations were performed in our center. Primary fascial closure was carried out in 282 cases (group A) and a Silastic prosthesis was temporarily interposed for fascial closure in 47 children (group B). One patient in whom a polyglactine mesh was used for primary and definitive closure of the wound was excluded from this study.

Donor and recipient data, which were collected retrospectively, included: donor age, weight, and type (cadaveric or living related), recipient age and weight, previous abdominal operations, indica-

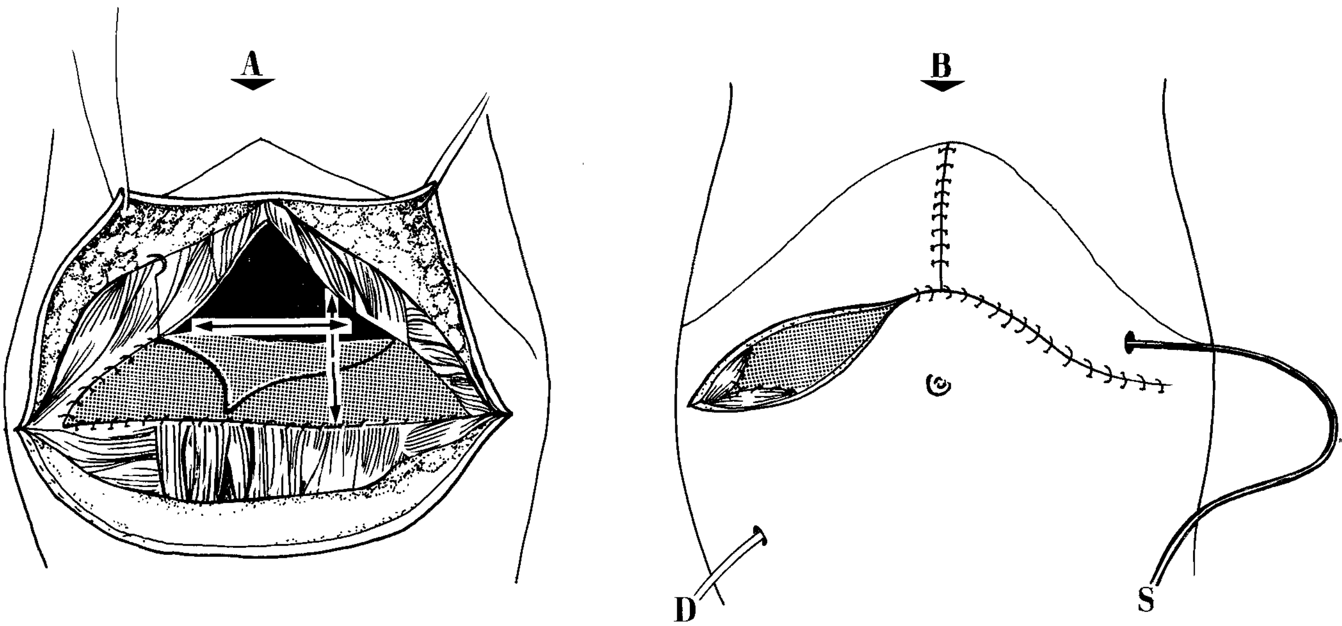

Fig. 1 A, B Temporary prosthetic abdominal closure: **A** A silicone reinforced sheet is sutured to the fascia after skin flaps are mobilized. Sheet spans were usually 3–5 cm (αβ); **B** The skin is closed over in a primary fashion (*D* abdominal drainage, *S* subcutaneous suction drainage)

Table 1 Indications for liver replacement in two groups of children according to the type of abdominal closure at transplantation: primary (group A – $n = 282$) or temporary silastic prosthetic closure (group B – $n = 47$)

Indication for liver replacement	Group A *N*	Group B *N*
Biliary atresia	155 (55%)	24 (51%)
Other liver diseases	63 (22%)	3 (6%)
Fulminant hepatic failure	20 (7%)	6 (13%)
Retransplantation	44 (16%)	14 (30%)

tion for liver replacement, clinical condition at transplantation [defined as elective (home-waiting), hospitalized, or ICU-bound], type of graft [full-size liver (FS-L), volume-reduced-size liver grafts (VR-L), or living related donor liver graft (LRD-L)], liver segments used (Couinaud's classification), and possibly related postoperative complications. Vascular (portal vein and hepatic artery) complications were defined as early (< 30 days) postoperative thrombosis or nonthrombotic flow problems necessitating reoperation. Primary graft dysfunction was defined as primary no or poor function in absence of vascular thrombosis, followed by loss of the graft. Parietal and abdominal problems were defined as clinical complications necessitating reoperation.

Within groups A and B, the type of graft was considered (FS-L, VR-L, or LRD-L) in order to compare certain data; in the VR-L and LRD-L subgroups, the number of segments used was also considered.

Technique and perioperative care

In cases where primary abdominal closure would have been too tight, preference was given to closure with a large Silastic prosthesis (silicone reinforced sheet). The prosthesis was sutured to the fascial layer after 3- to 5-cm mobilization of the skin and subcutaneous layer from the former fascia in order to perform direct skin closure over the prosthesis. In most cases, a large "three-pointed star" prosthesis was used for closure because the abdomen had been opened in an inverted-T fashion (Fig. 1). The size and tailoring of the prosthesis were left to the surgeon's own judgement and were adapted in order to achieve parietal closure with no or low tension; usually, a 3- to 5-cm span was enough (Fig. 1). After a drain was positioned in the free subcutaneous space, the subcutaneous fascia and the skin were sutured. Local and systemic antimicrobial prophylaxis was similar in both groups.

In the absence of postoperative complications, the removal of the prosthesis was planned between day 8 and day 10, allowing for a direct fascial closure. At the time of removal, bacteriological sampling was routinely performed. The skin was then closed using intracutaneous running sutures.

Statistical analysis

Numerical values were expressed as mean ± SD. Statistical analysis was performed using Student's *t*-test, the chi-square test, or Fisher's exact test, when appropriate. *P* was considered significant when it was below 0.05. Survival was compared using actual or actuarial Kaplan-Meier rates.

Results

Indications for liver replacement are detailed in Table 1. Fulminant hepatic failure and failure of a previous graft (high-risk recipients) represented 23% and 43% of the patients in groups A and B, respectively

Table 2 Primary (group A) or temporary silastic prosthetic (group B) abdominal closure after pediatric liver transplantation: clinical use according to the type of liver graft transplanted

Type of graft	Liver segments used[a]	Group A (n = 282) N	Group B (n = 47) N	A + B Temporary prosthetic closure per type
Cadaveric donor				
Full-size liver graft	All segments	102 (36%)	8 (17%)	7%
Volume-reduced liver graft[a]		158 (56%)	30 (64%)	16%
Left-lobectomized liver graft	1, 4, 5, 6, 7, 8	2	–	–
Right liver graft	1, 5, 6, 7, 8	4	–	–
Left liver graft	2, 3, 4	90	5	5%
Left liver lobe graft	2, 3	62	25	29%
Living related donor		22 (8%)	9 (19%)	29%
	2, 3, 4	2	0	–
	2, 3	20	9	31%

[a] According to Couinaud's classification

Table 3 Donor-recipient size mismatch at liver transplantation: comparison according to the type of graft and whether primary (group A) or temporary silastic prosthetic abdominal closure (group B) was performed

	Group A (n = 282)		Group B (n = 47)		P*
	Mean	SD	Mean	SD	
Full-size liver graft					
Recipient weight (kg)	16.8	13.5	11.35	3.5	0.3
Donor-to-recipient weight ratio (ratio)	1.3	0.5	1.7	1.1	0.08
Volume reduced liver graft					
Recipient weight (kg)	13.6	7.2	9.7	4.5	< 0.01
Donor-to-recipient weight ratio (ratio)	4.6	2.1	7.3	3.6	< 0.01
Living related donor liver graft					
Recipient weight (kg)	11.4	4.3	8.3	3.6	0.07
Donor-to-recipient weight ratio (ratio)	6.4	3.1	9.1	3.7	0.05

* Bilateral unpaired t-test

($P < 0.01$). There was no significant difference between the two groups with regard to the clinical condition at the time of transplantation or to whether the patient had had previous abdominal surgery or not (data not shown).

SP-C was used significantly more often when segment 2 + 3 grafts were used, either from cadaveric or living related donors (SP-C was used in 29% and 31% of the cases, respectively), than when other types of grafts were implanted (FS-L 7%; segment 2 + 3 + 4 graft 5%; other type 0%; Table 2).

Within subgroups (Table 3), SP-C was associated with a smaller recipient weight, although this only reached statistical significance in the VR-L subgroup. There was a significantly higher donor-to-recipient weight ratio in all subgroups when SP-C was performed after implantation of VR-L or LRD-L grafts.

The Silastic prosthesis was removed in one step within the first 3 weeks after transplantation in 35 patients (8.9 ± 3.8 days; median 9 days) and a direct fascial closure was then achieved. Four patients underwent a surgical revision during the 1st week (due to vascular problems in two cases and hemostasis in the other two); the prosthesis was kept in place and removed after 1–4 weeks. In three cases, the prosthesis was not removed because the patient died, and in three other cases, the prosthesis was removed early because of retransplantation. In the last two patients, the prosthesis was reduced gradually (in two and three steps, respectively); in one of these two cases, a small polyglactine mesh was used for closure of the epigastric part of the wound only, and this led to a localized incisional hernia that was surgically treated 5 years later. Incisional hernia was not reported where direct fascial closure was performed during a second operation in any patient in group B; however, five patients in group A had to be reoperated because of incisional hernia.

The minimum follow-up period was 6 months. Postoperative complications (Table 4) were similar in both groups, and none was related to the technique itself. Hepatic artery thrombosis (more frequent, but not significantly so, in group A) was significantly correlated with small-sized liver donors throughout the series, and there was usually no major size mismatch in these cases. Portal vein thrombosis occurred in six patients in group B; in one case, thrombosis occurred within 24 h after removal of the prosthesis, and in four other cases, the donor-to-recipient weight ratio was greater than 10. More-

Table 4 Primary (group A) or temporary silastic prosthetic abdominal closure (group B) after liver transplantation in children: postoperative complications

		Group A (n = 282) N	Group B (n = 47) N	P
Vascular[a]	– Hepatic artery	27 (9.60 %)	2 (4 %)	NS
	– Portal vein	12 (4.20 %)	6[b] (13 %)	NS
Graft lost due to dysfunction		23 (8.20 %)	2 (4 %)	NS
Incisional	– Hernia	5 (1.80 %)	1[c] (2 %)	NS
	– Fluid loss	3 (1.00 %)	1 (2 %)	NS
Abdominal abscess/collection		12 (4.20 %)	2 (4 %)	NS

[a] Defined as early (< 30 days) postoperative thrombosis or nonthrombotic flow problems necessitating reoperation
[b] One portal vein thrombosis occurred immediately after abdominal wall prosthesis removal
[c] Localized hernia after partial final closure using polyglactine mesh

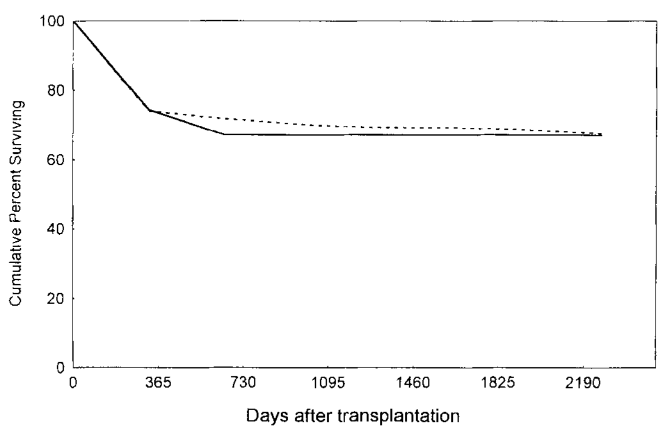

Fig. 2 Actuarial graft survival after conventional direct abdominal closure (*dotted line*) or temporary Silastic prosthetic abdominal closure (*solid line*)

over, the fact that four of these six patients underwent transplantation for fulminant hepatic failure must be taken into account since these latter patients, at the time of transplantation, have a relatively small abdominal cavity compared to cirrhotic patients with hepatomegaly and ascites.

The results of bacteriological cultures taken at prosthesis removal were available in 41 cases: culture was negative in 29 cases and positive in 5 cases. In five other cases, it was negative after 48 h but positive after prolongation and enrichment of cultures. In two other cases, although a first specimen provided during early surgical revision was positive, the sample taken at prosthesis removal was negative. None of the patients who had a positive culture developed any related infectious complications later.

The 3-month graft survival rate was 80 % in both groups. The 5-year graft actuarial survival rates were 69.1 % and 68.1 %, respectively, in groups A and B (P = NS; Fig. 2).

Discussion

Implantation of relatively oversized liver grafts, either full-size or volume-reduced liver grafts, is not rare in pediatric liver transplantation [4, 24, 25, 28] and can be associated with difficult primary closure. After tight primary abdominal wound closure, various complications have been reported, including: wound dehiscence [25], partial liver necrosis [4, 7, 9, 25, 27], subcapsular hepatic necrosis [1], vascular compression [7, 17] or thrombosis [2, 3, 25], and abdominal tamponade with diaphragmatic palsy [2, 12, 27]. In order to avoid these problems, a number of solutions have been proposed in the literature. These include: the preoperative creation of a pneumoperitoneum [6], the use of a monosegmental liver graft [13, 15], a secondary graft reduction (at the end of the transplantation or as a secondary operation) [7, 26], complete gut emptying and abdominal expansion by manual stretching [16], splenectomy at the end of the operation [8], closure of the skin only [10], definitive patch closure [30], no closure of the abdomen [2, 5], or delayed closure of the fascia with temporary interposition of prosthetic material [4, 14, 17, 21, 23]. In the latter three closure techniques, the skin is not sutured and thus has to close by second intention, resulting in a less esthetically correct aspect.

Our technique is original in that the skin is mobilized and closed over a suction drain. It avoids excessive additional postoperative wound care and decreases the risk of incisional fluid loss and of direct wound or abdominal infection [14 ,17, 23]. The prosthetic material is completely removed within the first few weeks postoperatively; in our experience, incisional hernia occurred in only one patient and was, in fact, related to the use of absorbable mesh at final closure. Moreover, contrary to all previously reported procedures, the skin is closed each time in a primary fashion: this latter practice, or the fact that skin is mobilized as flaps, has not been related to any clinical infections or complications. On the contrary, it has resulted in a normal and esthetically correct aspect, very similar to immediate primary closure.

From our data, the major advantage of this method is that it avoids tight abdominal closure when the graft is oversized, due either to misevaluation of the exact graft volume (even after volume reduction) and liver edema, or to decreased available abdominal space for other reasons, such as intestinal edema or distension [14, 20, 21, 23, 25]. The use of SP-C allows for the temporary enlargement of the available abdominal space and permits a more comfortable accomodation of the liver graft in a small abdomen. This also makes a low-pressure abdominal closure possible, thereby lowering the risk of compression that can compromise the liver's vascular perfusion, as suggested by Payen et al. [19], who reported a 26% decrease in portal flow and a 13.8% decrease in arterial liver perfusion at abdominal closure. This hypothesis is supported by the finding that graft loss due to dysfunction was only 4% in our group B compared to a 8.2% rate in group A despite size mismatch, which was significantly higher in group B.

Overall, there was no disadvantage of using this technique, except for the need to perform a second procedure to gain final closure. A common clinical observation was that the oversized graft rapidly decreased in size. This has already been reported and is probably related to edema resorption and/or real liver shrinkage by adaptive processes [11]. This reduction in graft size allowed for a delayed, but direct, abdominal closure in a primary fashion, in one step for the majority of patients. The final primary closure of fascia and skin probably helped to avoid further incisional problems, which are reported with variant techniques [14, 19]. There were no complications related to the use of the SP-C, and graft survival rates were similar in both groups. Excellent results were thus achieved in group B since there was a significantly higher proportion of high-risk indications in this group ($P < 0.01$).

Increasing experience and confidence allowed the authors to extend the acceptance criteria for donor-to-recipient size mismatchning, as shown by the high donor-to-recipient weight ratio in the VR-L subgroup (mean 4.6 vs 7.3 in groups A and B, respectively; $P < 0.01$). This approach culminated in our most recent experience, when large, living related donor livers were grafted successfully in very small recipients with temporary prosthetic closure (mean donor-to-recipient weight ratio in group B 9.3; Table 2) and a very low morbidity, as we have already reported [18, 29]. Graft survival was similar in groups A and B, which confirms that good results can be achieved with a significantly higher size mismatch, provided an alternative technique is used for closure of the abdomen without excessive tension.

In conclusion, this technique for delayed primary closure of the abdominal wall can benefit patients receiving size-mismatched liver grafts. We have seen how it avoids unnecessary tight wound closure, which would probably increase the risk of complications. The closure procedure we describe is similar to procedures previously reported except for the fact that the skin can be closed. This is a very useful variation that is not only free of related complications but also esthetically preferable. The major advantage of the technique is that it enables very small children to receive an adult-size liver graft from a cadaveric or living related donor, children who otherwise would have to remain on the waiting list much longer and, consequently, run the risk of clinical deterioration with time.

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