ABDOMINAL MULTIVISCERAL TRANSPLANTATION\textsuperscript{1,2}

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Under FK506-based immunosuppression, 13 abdominal multivisceral transplantations were performed in 6 children and 7 adults. Of the 13 recipients, 7 (53.8\%) are alive and well with functioning grafts after 9 to 31 months. Six recipients died: three from PTLD, one from rejection, one from sepsis, and one from respiratory failure. In addition to rejection, postoperative complications occurring in more than isolated cases included PTLD (n=6), abdominal abscess formation (n=5), pancreatitis (n=3), and ampullary dysfunction (n=2). In addition, infection by enteric microorganisms was common during the early postoperative period. Currently, all 7 survivors are on an oral diet and have normal liver function. Two recipients (one insulin-dependent) require antidiabetes treatment, in one case following distal pancreatectomy and in the other after two episodes of pancreatic rejection. Thus, abdominal multivisceral transplantation is a difficult but feasible operation that demands complex and prolonged posttransplantation management. It is not yet ready for application and awaits a better strategy of immune modulation.

Abdominal multivisceral transplantation was developed experimentally more than 30 years ago (1, 2). The procedure was extremely difficult, yielding >5-day survival in only 5 of 39 untreated animals. No clinical application of multivisceral transplantation could be envisioned at that time. In 1989, we first reported multivisceral transplantation in two children who had short bowel syndrome and total parenteral nutrition (TPN)\textsuperscript{*} induced liver failure (3). The first patient died during the early postoperative period. Six children and 7 adults.

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\textsuperscript{*} Abbreviations: GVHD, graft-versus-host disease; PTLD, post-transplant lymphoproliferative disorder; TPN, total parenteral nutrition.
the immediate postoperative period, but the second patient survived under cyclosporine-based immunosuppression with the immediate postoperative period. but the second patient have been reported. All eight patients died. with the longest well-functioning organs for 192 days. Including these two substituted at our center in May 1993. From October 1991 to the end of 1993, 13 patients underwent multivisceral transplantation at our center, 10 as a primary procedure and 3 years old and 7 adults with a mean age of 32.0 ± 7.1 years (age range 1.6 years to 44.8 years). Ten were primary recipients, and the other 3 had already failed a lesser intraabdominal transplant procedure. The procedure had to be abandoned in 2 additional candidates because of excessive bleeding during preliminary dissection of the native organs; both died. The indications for the 10 primary recipients included short bowel syndrome with (n=4) or without (n=3) TPN-related liver failure, mesenteric venous thrombosis with end-stage liver failure (n=1), juvenile polyposis (n=1), and malignant endocrine tumor (n=1). Although isolated intestine or combined intestine and liver grafting was considered for the short bowel patients, multivisceral transplantation was chosen because of the existence of thromboses of both the celiac axis and the superior mesenteric artery (n=3). TPN-related liver and pancreas failure (n=3), and pseudo-obstruction affecting the entire gastrointestinal tract (n=1). The 3 patients undergoing rescue multivisceral transplantation had undergone graft removal 2 months previously due to rejection of an isolated intestinal graft (n=1) or were bearing a rejecting intestine-liver (n=1) or liver (n=1) graft. The last patient also had intestinal pseudo-obstruction since birth and should have undergone a multivisceral transplantation on the first occasion. The features of the 13 recipients are summarized in Table 1.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Preoperative TPN</th>
<th>Graft</th>
<th>Hospitalization</th>
<th>Survival</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA &amp; SMA thrombosis</td>
<td>36 months</td>
<td>0.5 mg/dL</td>
<td>MV without colon</td>
<td>60 days</td>
<td>&gt;944</td>
</tr>
<tr>
<td>CA &amp; SMA thrombosis</td>
<td>3 months</td>
<td>1.3 mg/dL</td>
<td>MV without colon</td>
<td>11 days</td>
<td>&gt;717</td>
</tr>
<tr>
<td>Failed liver/intestine transplantation</td>
<td>50 days</td>
<td>22 mg/dL</td>
<td>MV with kidney</td>
<td>23 days</td>
<td>&gt;57</td>
</tr>
<tr>
<td>Volvulus</td>
<td>15 days</td>
<td>4.6 mg/dL</td>
<td>MV without colon</td>
<td>43 days</td>
<td>&gt;641</td>
</tr>
<tr>
<td>Pseudo-obstruction</td>
<td>54 days</td>
<td>26.1 mg/dL</td>
<td>MV</td>
<td>30 days</td>
<td>&gt;559</td>
</tr>
<tr>
<td>Malignant neuroendocrine tumor</td>
<td>0 days</td>
<td>0.7 mg/dL</td>
<td>MV</td>
<td>21 days</td>
<td>&gt;49</td>
</tr>
<tr>
<td>Juvenile polyposis</td>
<td>22 days</td>
<td>0.5 mg/dL</td>
<td>MV without liver</td>
<td>17 days</td>
<td>&gt;420</td>
</tr>
<tr>
<td>Budd-Chiari syndrome</td>
<td>0 days</td>
<td>3.7 mg/dL</td>
<td>MV</td>
<td>120 days</td>
<td>197</td>
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<tr>
<td>Pseudo-obstruction after liver transplantation</td>
<td>19 days</td>
<td>0.4 mg/dL</td>
<td>MV</td>
<td>7 days</td>
<td>&gt;355</td>
</tr>
<tr>
<td>Volvulus</td>
<td>24 days</td>
<td>8.3 mg/dL</td>
<td>MV</td>
<td>26 days</td>
<td>&gt;198</td>
</tr>
<tr>
<td>Gardner's syndrome</td>
<td>26 days</td>
<td>18.1 mg/dL</td>
<td>MV</td>
<td>41 days</td>
<td>&gt;281</td>
</tr>
<tr>
<td>Failed intestine transplantation</td>
<td>163 days</td>
<td>1.2 mg/dL</td>
<td>MV</td>
<td>91 days</td>
<td>147</td>
</tr>
<tr>
<td>Intestinal atresia</td>
<td>19 days</td>
<td>58.2 mg/dL</td>
<td>MV</td>
<td>58 days</td>
<td>&gt;58</td>
</tr>
</tbody>
</table>

* CA: celiac axis; SMA: superior mesenteric artery.
* TPN: total parenteral nutrition.
* MV: multivisceral grafts include the stomach, liver, pancreas, intestine, and colon.
* As of May 15, 1994.
FIGURE 1. Scheme of multivisceral transplantation: (A) Multivisceral transplantation without colon; (B) Multivisceral transplantation with colon; (C) Multivisceral transplantation without liver and with rectal reconstruction by a pull-through technique; (D) Multivisceral transplantation with bilateral kidneys.

to the proximal end of the remaining recipient colon (Fig. 1B). Cholecystectomy was carried out in all cases, and a catheter was introduced via the cystic duct into the common bile duct for biliary decompression and postoperative cholangiogram. A tube jejunostomy, with terminal ileostomy (n=5), colostomy (n=2), or Bishop-Koop ileostomy (n=6), was made for enteral decompression, enteral feeding, and a route for endoscopic examination.

Modification of the procedure was required in some cases. Because of the profuse hemorrhage that precluded the operation in two patients with mesenteric venous thromboses, the celiac axis and the superior mesenteric artery were occluded in Case 8 by angiographic placement of intraaortic balloons immediately before starting the procedure. This adult patient tolerated this modification and survived the operation with a blood loss of 26 units. In a pediatric patient with juvenile polyposis and a normal liver, the liver was omitted from the multivisceral graft (Fig. 1C). Her rectum was reconstructed by a pull-through technique. Kidneys were included with the multivisceral grafts in another pediatric patient who had renal insufficiency (Fig. 1D).

Postoperative management. Management of multivisceral transplant recipients after transplantation was the same as for isolated intestinal recipients, including methods of nutritional management and prevention of infection. FK506, steroids, and prostanolidin E1 (Prostin) were used for immunosuppression. Intravenous FK506 (0.1
to 0.15 mg/kg/day) was started intraoperatively, and was then switched to oral FK506 (0.3 mg/kg/day or slightly less) when the patient became tolerant to enteral feeding. Trough plasma levels of FK506 were maintained at 2–3 ng/ml for the first month. 1–2 ng/ml thereafter (Fig. 2). Methylprednisolone 1 g in adults or hydrocortisone in children was given intravenously immediately after the grafts were revascularized and was followed by rapid tapering of prednisone over 5 days after transplantation. Maintenance progestin EC (0.6 to 0.9 mg/kg/hr) was continued until intravenous FK506 was stopped.

Monitoring of intestinal graft rejection was based on clinical findings, endoscopic examination, and histopathological study of endoscopy-guided biopsies. Treatment of intestinal rejection depended upon its severity as described before (8). Routine liver function tests were used to monitor liver rejection, and liver biopsies were taken if needed. Frequent measurements of amylase and lipase levels in blood and/or fluid in Jackson-Pratt drains were used to monitor pancreas rejection.

Assessment of graft function. Body weight, volume of stool output, frequency and nature of the stool, and dependency on TPN, enteral feeding, and/or oral diet were repeatedly evaluated to assess intestinal graft function. In addition, absorptive function was directly measured by d-xylose test and by 72-hr fecal fat secretion. Measurements of gastric emptying by radiolabeled test meals, intestinal transit time by a barium follow-through, and contractile activity by manometry were performed periodically to determine the motility of the gastrointestinal tract. Graft function of the liver and the pancreas was determined by serial determination of blood chemistries. Pancreatic endocrine function was periodically studied in long-term survivors by measuring blood glucose and c-peptide levels after intravenous injection of 0.5 g/kg glucose.

RESULTS

Survival. Of the 13 patients, 6/10 given primary grafts and 1/3 in which the multivisceral procedure was secondary are currently alive and well with follow-up of 9 to 31 postoperative months (Tables 1 and 2). Six are at home while one pediatric patient is currently hospitalized for the treatment of posttransplant lymphoproliferative disease (PTLD); this last patient’s antidonor lymphocytotoxic crossmatch was positive. With an actual patient survival of 7/13 (53.8%), the actuarial patient survival rates by the life-table method at 3 months, 6 months, one year, and 2 years are 76.9%, 69.2%, 53.8%, and 53.8%, respectively.

Causes of mortality. The 6 deaths occurred 1.5, 2.2, 5.65, and 6.5 months after the multivisceral transplantation (Table 1). Three of the 6 deaths were caused by PTLD, one by respiratory failure, one by rejection, and one by sepsis (Table 1). Two of the 3 deaths caused by PTLD occurred at 49 days and 198 days after primary transplantation; the third was 57 days after replacement of a rejected combined liver-intestine graft. In the last case, the rejection had followed reduction of immunosuppression at 10 months for the treatment of PTLD in the donor colon after the primary transplantation. At the time of the rescue multivisceral transplantation 15 months following the primary procedure, no PTLD lesions were detectable in the specimen or elsewhere.

Patient 8, who died from cytomegalovirus (CMV) infection, was CMV seronegative pretransplant and received grafts from a CMV-seropositive donor: although the infection was controlled, the lungs were destroyed. Patient 12, who was rescued from rejection of her isolated intestinal graft, was found to have a resistant intraabdominal infection with Torulopsis glabrata in the abdominal cavity at the time of retransplantation and died from this 5 months later.

Rejection. Ileal biopsies collected via the terminal ileostomy or the Bishop-Koop ileostomy showed rejection in 11 (84.6%) of the 13 recipients. On 162 occasions, the ileal biopsies were taken simultaneously with sampling from other sites: stomach (n=50), duodenum and/or jejunum (n=27), or colon (n=85). When the ileum had histological evidence of acute rejection, rejection was also found at the aforementioned sites at 0% (0/3), 25% (2/8), and 43.7% (7/16), respectively. Isolated rejection at these sites was found only once, at the jejunum in patient 7. Acute rejection of the stomach was never seen.

Rejection of the liver and the pancreas was less frequent.
and serious, with an incidence by clinical criteria of 46.2% (6/13) for the liver and 30.1% (4/13) for the pancreas. Increased immunosuppression for liver rejection was not required, but severe acute pancreatitis was caused by rejection in one patient after immunosuppression had been reduced.

No evidence of graft-versus-host disease (GVHD) was detected clinically or in the tissue samples (including 3 post-mortems) in any of the cases.

**Complications.** All recipients, except patient 9, had significant or life-threatening complications (Table 3), of which the 6 examples of PTLD were the most common. Of the 3 patients who survived PTLD, 2 have resolved lesions and the third is improving. The 5 intraabdominal abscesses were caused by leakage from the gastrostomy site (n=1), enteric perforation (n=2), and necrotizing pancreatitis (n=2). The pancreatic abscesses were apparently caused by preservation; one patient underwent total pancreatectomy (patient 8) and the other distal pancreatectomy (patient 11). Patient 12, who had necrosis and scarring at the muscle layer of the intestinal wall, required 5 separate enteric resections after each of 5 perforations over a time span of 1.5 months. Two adult recipients required transient dialysis for renal failure to which FK506 and nephrotoxic antibiotics appeared to be contributory (Figure 2). A persistent elevation of cannular enzy­mases from ampullary dysfunction in patient 2 was relieved with endoscopic papillotomy, while another patient with this complication did not require intervention.

During the early postoperative period, enteric microorgan­isms, including *Enterococcus faecium*, *Enterococcus faecalis*, *Escherichia coli*, and *Klebsiella*, were cultured from the peritoneal fluid and/or wound discharge of 12 (92.3%) of the 13 patients, in the sputum and/or bronchoalveolar lavage of 9 (69.2%), and in the blood and/or catheters of 12 (92.3%). All of the recipients who survived for more than 2 months after surgery developed a normal bacterial flora of the stool with bacterial overgrowth with >10⁶ colony forming units/ml.

**Graft function.** All 7 surviving recipients as well as patients who died after more than 3 months gained or maintained their body weight exclusively on an unrestricted oral diet (Table 2). Among the current survivors, the latest d-xylose absorption test was normal in all studied, but fecal fat excretion was universally elevated, especially in patient 2 who had 2 episodes of pancreas rejection. Motility function of the gastrointestinal tract was highly variable, and was influenced by the duration of follow-up. The trend in long survivors suggested recovery of normal gastric emptying and intestinal transit after one year (Fig. 3). However, manometric studies commonly showed that antral and intestinal contractions were hypoactive during fasting and after feeding, with absent migrating motor complex propagation, even later than one year.

Liver function is normal or near-normal in all of the surviving patients. Two of them require treatment for hyperglycemia caused by distal pancreatectomy (patient 11) or pancreas rejection (patient 2)—one with insulin and the other without. Changes in blood glucose and C-peptide in these 2 patients during an intravenous glucose tolerance test are shown in Figure 4.
postoperative days. Glucose was given at a dose of 0.5 mg/kg. Shaded areas indicate range obtained from 5 normal controls. POD: postoperative days.

**Figure 3.** Blood level of glucose and C-peptide after intravenous glucose tolerance test. Glucose was given at a dose of 0.5 mg/kg. Shaded areas indicate range obtained from 5 normal controls. POD: postoperative days.

**Figure 4.** Barium follow-through of multivisceral recipient (patient 10). (A) 30 min; (B) 2 hr; (C) 3 hr; (D) 4 hr.

**DISCUSSION**

Our experience and that of others with multivisceral (3–6, 8, 9), liver-intestinal (7, 8, 12), and isolated intestinal (13–15) transplantation have delineated what can and cannot be achieved with any of these procedures using current management methods. As with liver transplantation through the 1970s, the procedures that include intestine are feasible but impractical means of therapy that are not yet ready for general use. Although half the multivisceral recipients were restored to near normal health, including relatively complete dietary rehabilitation, the early and late mortality was excessive, with a lengthy list of complications even for patients who successfully ran the gauntlet of the first postoperative year.

The problems were much the same as those still seen with conventional liver transplantation, but they have been far more frequent and serious: incomplete control of rejection with consequent bacterial translocation throughout the damaged intestinal graft, a high rate of lethal septic complications, and the extraordinary 46% incidence of lymphoproliferative disorders. The most encouraging notation was the total absence of GVHD, which was feared at one time to make the intestine a forbidden organ for transplantation unless there was a perfect MHC match (16).

The next large advance is predicted to turn on a strategy that would have been an inconceivable proposal with the previous paradigm of transplantation immunology. However, the freedom from GVHD of these and other kinds of human intestinal recipients (7–9) can now be explained by the mutual canceling interactions of the coexisting cell populations following the transplantation of any whole organ that we have postulated to be the seminal mechanism of graft acceptance (17, 18). Lymphoid depletion of the graft, which was the consensus of workers in the intestinal transplantation field until recently (19–22), unbalances the graft-host-immunologic relation and appears to be unnecessary and probably contraindicated. When T cell depletion of the intestine was attempted in earlier clinical cases, there was an almost universal incidence of B cell lymphomas (3, 4, 6).

Armed with the realization that persistent spontaneous chimerism begins within minutes by migration of donor nonparenchymal cells from all grafts, and most dramatically from organs with a large hematolymphopoietic constituency, this timing has been simulated by perioperative infusion of $3 \times 10^9$/kg unaltered bone marrow cells in 45 consecutive unconditioned human recipients of kidneys, livers, hearts, and lungs under conventional FK506-prednisone immunosuppression. The freedom of these patients from GVHD (trivial only in 2), their benignancy of recovery (all are well), and the demonstration of stable macrochimerism in the first 18 after 4 to 17 months (23) has generated plans to use the same treatment protocols for future intestinal recipients.

**REFERENCES**

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Central nervous system (CNS) involvement occurred in 289 of 1332 patients (22%) with posttransplant non-Hodgkins lymphomas. The average time of appearance was 33 months (range 3 weeks to 248.5 months) posttransplantation. Lesions were confined to the CNS in 159 patients (55%), while 130 (45%) had involvement of other organs. Lesions involved the brain in 254 patients (88%), the brain and spinal cord in 5 (2%), the spinal cord in 2 (1%), unspecified locations in the CNS in 13 (4%), the meninges in 8 (3%), and the cerebrospinal fluid (CSF) in 7 (2%). All patients whose only involvement of the CNS was the meninges or CSF had lymphomas involving multiple organs. Many tumors (48%) appeared within one year after transplantation. Brain lesions were frequently multicentric in distribution. Ninety-one (31%) of the 289 patients had no treat­ment and died, 70 (77%) of their malignancies and 21 (23%) from other causes. Of 198 patients who received treatment 124 (63%) died of their malignancies; 40 (20%) died of other causes, including 17 patients who had had complete remissions following treatment; 22 (11%) are currently alive and in complete remission; and 12 (6%) are alive and still undergoing therapy. The treatment of choice is local radiotherapy to the brain, which either alone (18 patients) or in combination with other modalities (14 patients) caused 32 of the 39 (82%) complete remissions. Ten of 30 patients with disease localized to the CNS survived more than 5 years, including 6 who survived more than 10 years. CNS lymphomas should be suspected whenever a transplant patient has neurologic symptoms however minor, and prompt work-up is essential to eliminate other possible causes. The dismal prognosis can be improved only by early diagnosis and prompt therapy.

The lymphomas are the most important group of all malignancies that occur de novo in organ transplant recipients. If nonmelanoma skin cancers and in situ carcinomas of the uterine cervix are excluded, as they are from most cancer

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