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The Multi-Organ Donor
**Selection and
Management**

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Donor Procurement for Intestinal Transplantation

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Although the intestine was one of the first organs to be transplanted experimentally, clinical intestinal transplantation has been unsuccessful until recently, primarily due to the absence of potent immunosuppressive agents.

Lillihei et al first reported intestinal transplant in humans in 1967 (1). A total of seven unsuccessful intestinal transplantations were performed before cyclosporine was introduced (2-5). Azathioprine, steroids, antilymphocyte globulin (ALG), or thoracic duct drainage were used for immunosuppressive therapy, but the patients died from technical failure, rejection, and sepsis. The longest survival was 76 days (5).

These poor clinical results, as well as the advent of total parenteral nutrition (TPN) in the early 1970s, prevented the development of clinical intestinal transplantation for more than a decade. Meanwhile, heart, liver, and kidney transplantation had rapidly become a more practical procedure, especially after the introduction of cyclosporine.

In 1985, Cohen et al performed the first intestinal transplantation using cyclosporine; however, the patient survived for only 10 days (6). Extensive survivals were first achieved with multivisceral transplantation in 1987 by Starzl et al (7) and with combined liver and intestinal transplantation in 1989 by Grant et al (8) using the cyclosporine-based immunosuppression. However, results of the isolated intestinal transplantation under cyclosporine were still unsatisfactory (6,9-15). Only

2 of 13 patients (15%) are currently alive with functioning grafts (12,15).

Since the advent of the potent immunosuppressive agent tacrolimus (FK 506), intestinal transplantation has become a feasible therapeutic option for patients with irreversible intestinal failure (16–18). During the past five years, 62 patients received intestinal grafts alone, combined with the liver, or as a part of multiviscera, at the University of Pittsburgh Medical Center.

In this current text, we present our clinical experience with intestinal transplantation, focusing on the selection and management of intestinal donors as well as the procurement and preservation of intestinal grafts.

TYPE AND INDICATIONS OF TRANSPLANTATION

Irreversible intestinal failure is defined as the inability to maintain nutrition or positive fluid and electrolyte balance without special support owing to the loss of absorptive surface or function of the native small bowel. Irreversible intestinal failure is the primary indication for intestinal transplantation and its causes for our 62 patients are summarized in Table 11-1. Currently, three different types of intestinal transplants (isolated intestinal, combined liver and intestinal, or multivisceral) can be performed, depending on the cause and severity of intestinal failure and the presence of extraenteric organ dysfunction.

Isolated intestinal transplantation is indicated for patients who have irreversible intestinal failure with no other organ dysfunction. This procedure is currently performed in selected patients who lack venous access for TPN because of major venous thrombosis or frequent line sepsis.

Table 11-1. Causes of Intestinal Failure

Children	No.	Adults	No.
Volvulus	8	Crohn's disease	7
Gastroschisis	7	Thrombotic disorder	7
Necrotizing enterocolitis	6	Intestinal trauma	4
Intestinal atresia	6	Desmoid tumor	4
Pseudo-obstruction	3	Intestinal adhesions	3
Microvillous inclusion disease	2	Intestinal polyposis	1
Intestinal polyposis	1	Pseudo-obstruction	1
Hirschsprung's disease	1	Volvulus	1

Surgical short gut syndrome, with loss of more than 80% of the small bowel, is the most common indication for isolated intestinal transplantation. The leading causes of intestinal resection in adults include abdominal trauma, Crohn's disease, surgical adhesions, Gardner's syndrome, desmoid tumor, and occlusion of the superior mesenteric vessels. Causes differ in the pediatric population and include necrotizing enterocolitis, intestinal atresia, midgut volvulus, and complicated gastroschisis. Two less common categories exist as indications for isolated intestinal transplantation. The first is chronic pseudo-obstruction, which is manifested by defective gastrointestinal motility due to either hollow visceral myopathy, neuropathy, or total intestinal aganglionosis. The second is impairment of absorptive and secretory capacity of the enterocyte to indicate permanent TPN therapy in patients with microvillous inclusion disease, autoimmune enteropathy, radiation enteritis, extensive inflammatory bowel disease, and massive intestinal polyposis.

Combined liver and intestinal transplantation is primarily indicated for patients who suffer from intestinal failure with TPN-related cholestatic liver failure. It is also the procedure of choice for patients with liver failure and concomitant thrombosis of the entire portomesenteric system. In these patients, enterectomy of the normally functioning native intestine is required. Simultaneous liver replacement, despite absence of the liver failure, is indicated only in patients with vascular thrombosis due to congenital coagulation defects (protein C or S, or antithrombin III deficiency). In some of these patients, multivisceral transplantation is inevitable because of concomitant vascular insufficiency of the remaining upper abdominal organs, including the stomach, duodenum, and pancreas.

Multivisceral transplantation is indicated for patients with irreversible failure of more than two of the abdominal visceral organs including the intestine. Generally, the liver, pancreas, stomach, duodenum, and intestine are implanted. The liver can be omitted from multiviscera if the patient has a normal native liver.

The common causes for these multivisceral failures are extensive thrombosis of the splanchnic vessels, massive gastrointestinal polyposis, and generalized chronic pseudo-obstruction. Multivisceral transplantation can also be attempted for patients with potentially curable abdominal malignancies that require upper abdominal exenteration.

Currently, intestinal transplantation is contraindicated for patients with significant cardiopulmonary insufficiency, history or presence of aggressive and incurable malignancy, persistent abdominal or systemic infection, and extensive atherosclerosis or severe autoimmune and immunodeficiency syndromes. Also, senior citizens (≥ 60 yr), patients with an inactive lifestyle, and those who failed alcohol or drug rehabilitation should not be candidates.

RECIPIENT OPERATION AND MANAGEMENT

An understanding of the recipient operation is important in performing the flexible procurement of intestinal grafts. The principles and details of the recipient operations have been described elsewhere (16–20). All recipients receive routine gut decontamination and intravenous antibiotics prophylactically.

In isolated intestinal transplantation, the superior mesenteric artery of the graft is anastomosed to the anterior wall of the recipient infrarenal aorta (Fig. 11-1). The venous outflow of the intestinal graft is drained into the recipient portovenous system in most cases; in a few instances, the recipient portal vein is anastomosed to the donor inferior vena cava. The proximal jejunum of the graft is anastomosed to either the jejunum or duodenum of the recipient. Distal anastomosis is done in patients who still have their native rectosigmoid colon. The donor ileum or donor colon is connected to the recipient colon with

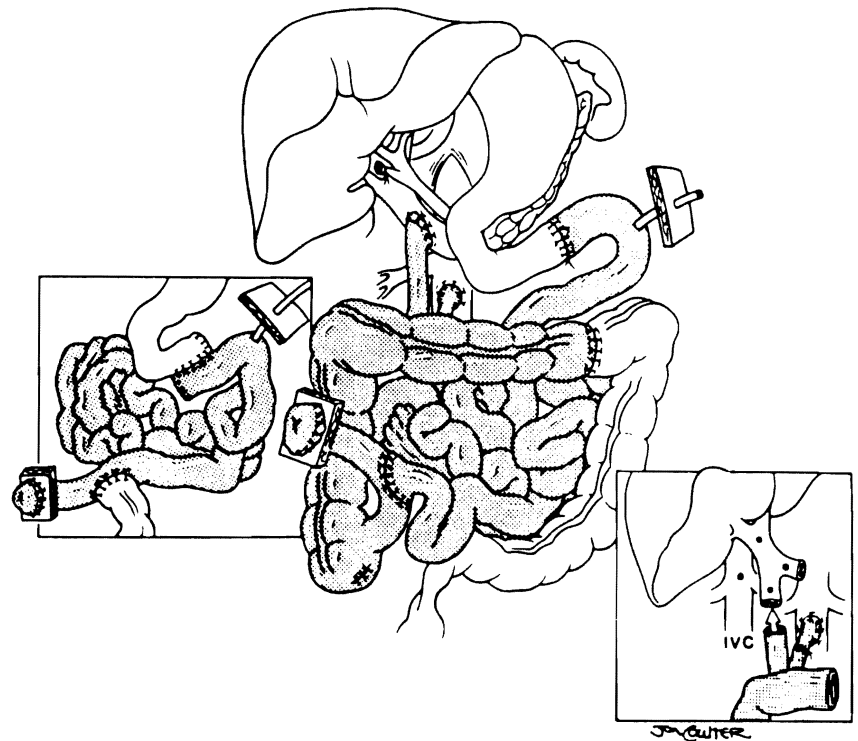


Figure 11-1. Isolated intestinal transplantation including one-half of the colon (*main figure*) or the small intestine only (*left insert*). Graft venous flow is drained end to side (*main figure*) or end to end (*right insert*) into the host portal system. IVC = inferior vena cava. (Reproduced by permission from Abu-Elmagd K, Todo S, Tzakis A, et al. Three years' clinical experience with intestinal transplantation. *J Am Col Surg* 1994;179:385–400.)

creation of the simple enterostomy or Bishop-Koop ileostomy. Construction of the temporary enterostomy facilitates clinical, endoscopic, and histologic monitoring of the graft. The Bishop-Koop ileostomy is performed in patients who receive the colon as part of the intestinal graft to provide easy access for ileoscopy. Terminal ileostomy or colostomy is performed in most of the patients who have lost their native rectosigmoid colon.

In combined intestinal and liver transplantation, the hepatic venous flow is reconstructed by the piggyback technique (21) (Fig. 11-2). The common arterial conduit of the entire graft is anastomosed to the recipient infrarenal aorta (Fig. 11-3). After reperfusion, the previously performed portocaval shunt is converted to a portoportal shunt by reanastomosing the recipient portal vein to the side of the graft portal vein (22). In patients whose portal vein is too short, or when the graft portal vein is too small, the recipient portocaval shunt is left in place permanently (see Fig. 11-2, right insert). The biliary tract of the new liver is reconstructed by performing a simple loop choledochojejunal

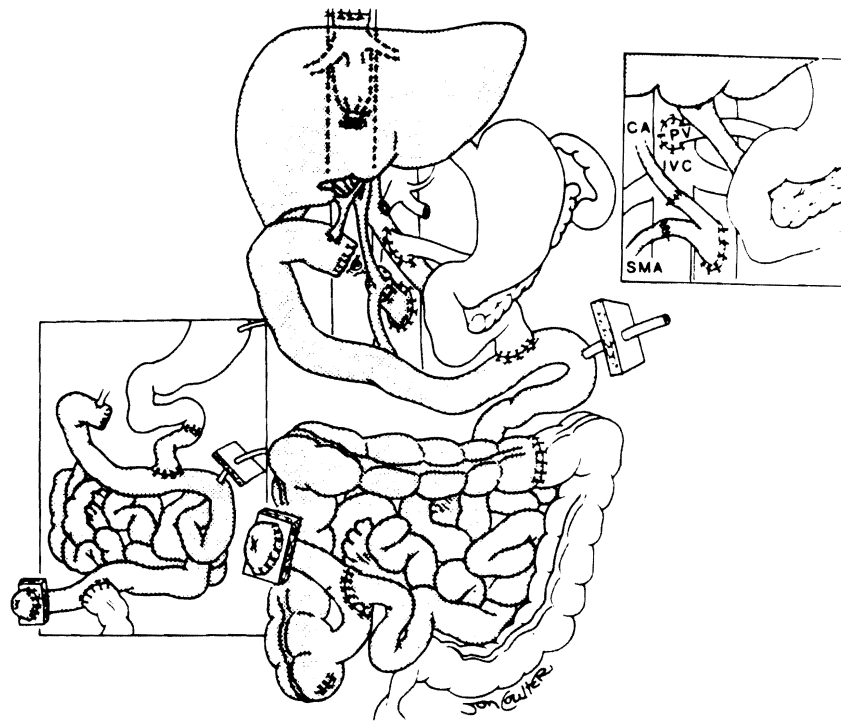


Figure 11-2. Combined liver and intestinal transplantation including part of the colon (*main figure*) or with small intestine only (*left insert*) is shown. The host portal vein (PV) is drained into the graft portal vein if possible. Otherwise, this blood is diverted into the vena cava (*right insert*). SMA = superior mesenteric artery; CA = celiac artery. (Reproduced by permission from Abu-Elmagd K, Todo S, Tzakis A, et al. Three years clinical experience with intestinal transplantation. *J Am Col Surg* 1994;179:385-400.)

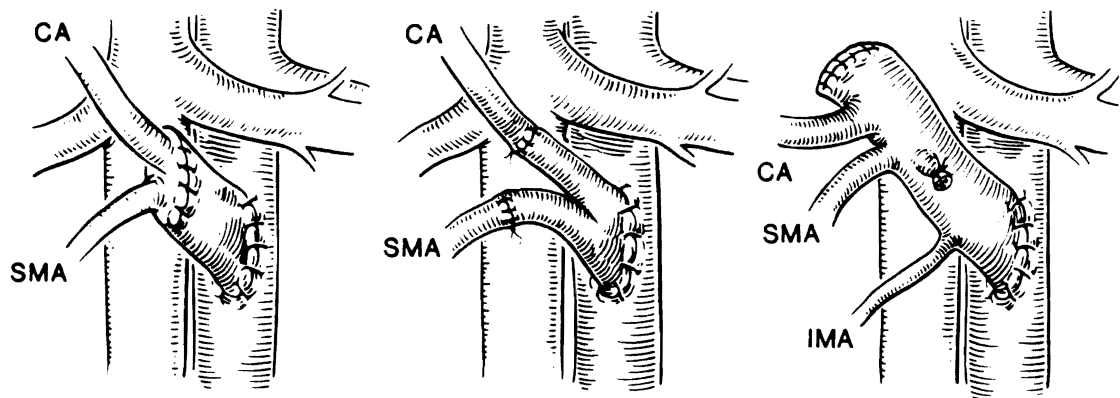


Figure 11-3. Arterial anastomosis of the combined liver and intestinal and multivisceral transplantation. Aortic conduit (*left*) in most of the recipient. Aortic bifurcation conduit (*middle*) and whole-abdominal aorta (*right*) are variations. IMA = inferior mesenteric artery. [Reproduced by permission from Furukawa H, Abu-Elmagd K, Reyes J. Technical aspects of intestinal transplantation. In: Braverman MH, Tawe RL, eds. *Surgical technology international 2*. San Francisco: Surgical Technology International, 1993:165-170.]

anastomosis. Continuity of the gastrointestinal tract is established in a fashion similar to that described for the isolated intestinal graft.

In multivisceral transplantation, as with the combined (liver-intestine) graft, vascular reconstruction includes both hepatic venous and graft arterial anastomoses (Fig. 11-4). The graft suprahepatic cava is anastomosed to the recipient hepatic veins (piggyback). The arterial conduit is anastomosed to the recipient celiac or infrarenal aorta. Proximal reconstruction of the alimentary tract is established by anastomosing the distal esophagus or the remaining portion of the stomach of the recipient to the anterior gastric wall of the graft. Distal continuity of the intestinal tract is established in the same way as isolated and combined intestinal grafts.

Postoperative immunosuppression is achieved with tacrolimus (FK 506), steroids, and, in selected cases, azathioprine. Recovery of intestinal graft function is assessed primarily by serial gastrointestinal radiographs, FK 506 oral pharmacokinetics, and D-xylose absorption test. Frequent anthropometric measures, serial serum albumin measurements, and trace element and fatty acid analyses are assessed to monitor and direct the nutritional management of these cases.

Intestinal allograft rejection is monitored using clinical, endoscopic, and histopathologic parameters. Surveillance endoscopy with multiple mucosal biopsies is performed once or twice a week for the first 3 months, and thereafter whenever it is clinically indicated. Acute graft rejection is treated either by augmenting tacrolimus (FK 506) therapy, steroid bolus, steroid recycle, or OKT3 based on the severity of the rejection episode (23).

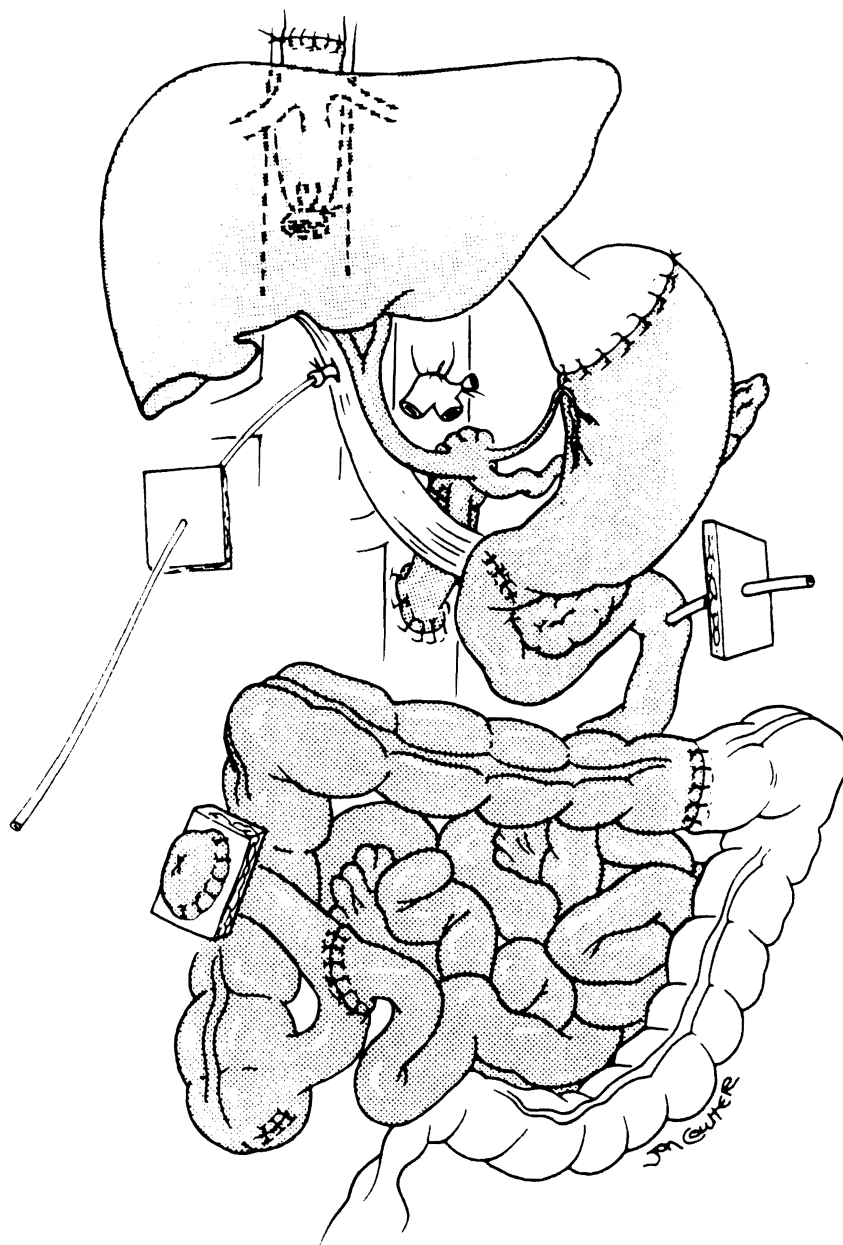


Figure 11-4. Multivisceral transplantation including the ascending and right transverse colon. Note that pyloroplasty or pyloromyotomy is performed and the bile flow is temporarily decompressed. (Reproduced by permission from Abu-Elmagd K, Todo S, Tzakis A, et al. Three years' clinical experience with intestinal transplantation. *J Am Col Surg* 1994;179:385-400.)

SELECTION AND MANAGEMENT OF DONORS

Grafts for intestinal transplantation are obtained from cadaveric donors. The general criteria for donor selection do not differ from those for liver donors. Young (<45 yr old), hemodynamically stable, local donors are preferred. Since the intestine is very sensitive to ischemia, a donor who has had a high dose of vasopressor agents or has a history of hypotension of long duration, cardiac arrest, and/or cardiopulmonary resuscitation should be avoided. Those with systemic infection and malignancy are also excluded. Donor size should be similar to or preferably smaller than that of the recipient, whose peritoneal cavity is usually shrunk secondary to previous repeated surgeries. ABO blood type should be identical between donor and recipient. Human leukocyte antigen (HLA) matching is not currently considered and is universally poor. Ideally, donors with positive lymphocytotoxic cross-match should be excluded. This policy is not presently applied at our institute because of the possibility of jeopardizing the donor organ by prolonged cold ischemia while waiting for the crossmatch result. No attempts are made to alter the graft lymphoreticular tissue with anti-lymphocyte preparations or other modalities. Cytomegaloviral (CMV)-seronegative donors are selected for all intestinal recipients. This policy was recently adopted to reduce the incidence of CMV disease, since recipients who receive CMV-seropositive grafts have significant high mortality (24).

All donors receive routine gut decontamination. The antimicrobial agents used are amphotericin B/nystatin (Mycostatin), aminoglycosides, and polymyxin E through a nasogastric tube. At the same time, ampicillin and cefotaxime are given intravenously every 6 to 8 hours and at the time of organ procurement.

The University of Wisconsin (UW) solution is used for in situ perfusion and simple cold storage of the entire graft. The total volume of the UW solution used for in situ perfusion is 1 to 2 liters for adult donors and 50 to 100 mL/kg for pediatric donors. When the colon is not included in the intestinal graft, no attempt is made to flush the lumen of the intestinal graft with UW or other cold solutions. When the colon is part of the intestinal graft, the lumen is flushed with 1 to 2 liters of chilled lactated Ringer's solution containing amphotericin B, aminoglycosides, and polymyxin.

DONOR OPERATIONS

A key factor in successful intestinal transplantation is the procurement of intestinal grafts of good quality and satisfactory anatomy. Anatomic

considerations are particularly essential at the time of intestinal procurement because the recipients require different types of intestinal transplantation, depending on the severity of extraenteric organ dysfunction. The logistics of the operative procedure have been described previously (19,20,25).

Isolated Intestine

The retrieval procedure starts with a cruciate abdominal incision (Fig. 11-5). The greater omentum is carefully dissected and separated from the transverse mesocolon. After the duodenum is kocherized, the cecum, ascending colon, and mesenterium are mobilized from the retroperitoneum. The right and middle colic vessels and appendiceal vessels are divided, sparing the ileal branches of the ileocolic artery. The ileum is divided at the ileocecal valve before the cross clamp.

Attention is then directed to the proximal jejunum, which is transected close to the ligament of Treitz. The third and fourth portion of

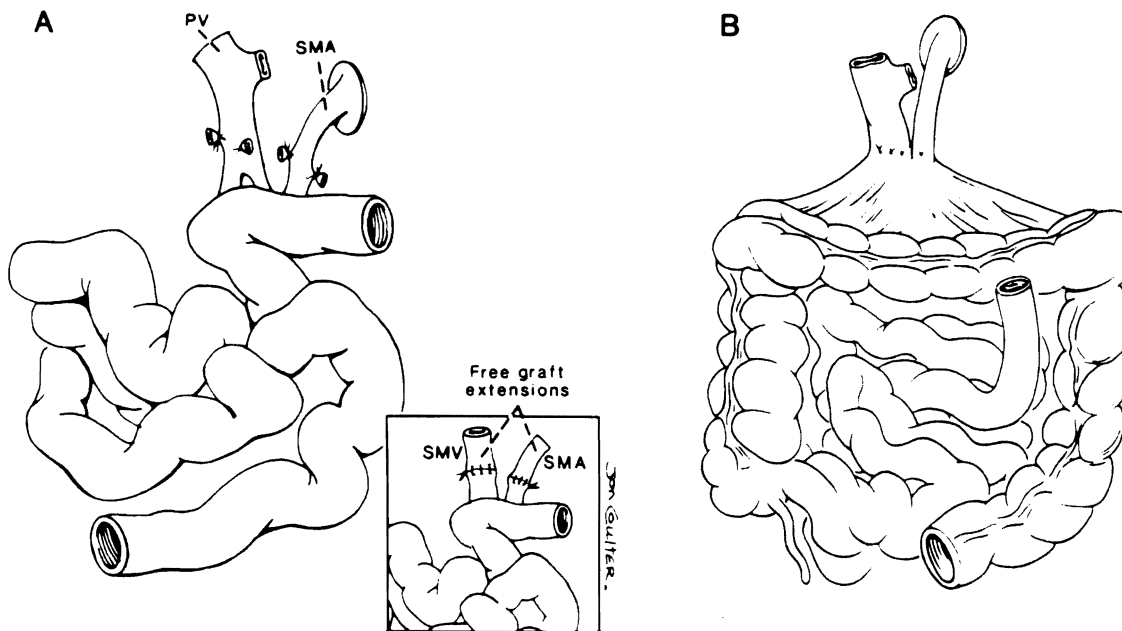


Figure 11-5. A. Isolated intestinal graft without colon full-length vascular pedicle of the superior mesenteric artery (SMA, with Carrel patch) and vein (SMV) (main figure). Note that the iliac arterial graft was used as an extension of the superior mesenteric artery (right insert). PV = portal vein. (Reproduced by permission from Todo S, Tzakis AG, Abu-Eimaga K, et al: Intestinal transplantation in composite visceral grafts or alone. *Ann Surg* 1992;216:223-234.) B. Graft with colon. (Reproduced by permission from Furukawa H, Abu-Eimaga K, Reyes J: Technical aspects of intestinal transplantation. In Braverman MH, Tawe RL, eds. *Surgical technology international 2*. San Francisco: Surgical Technology International, 1993:165-170.)

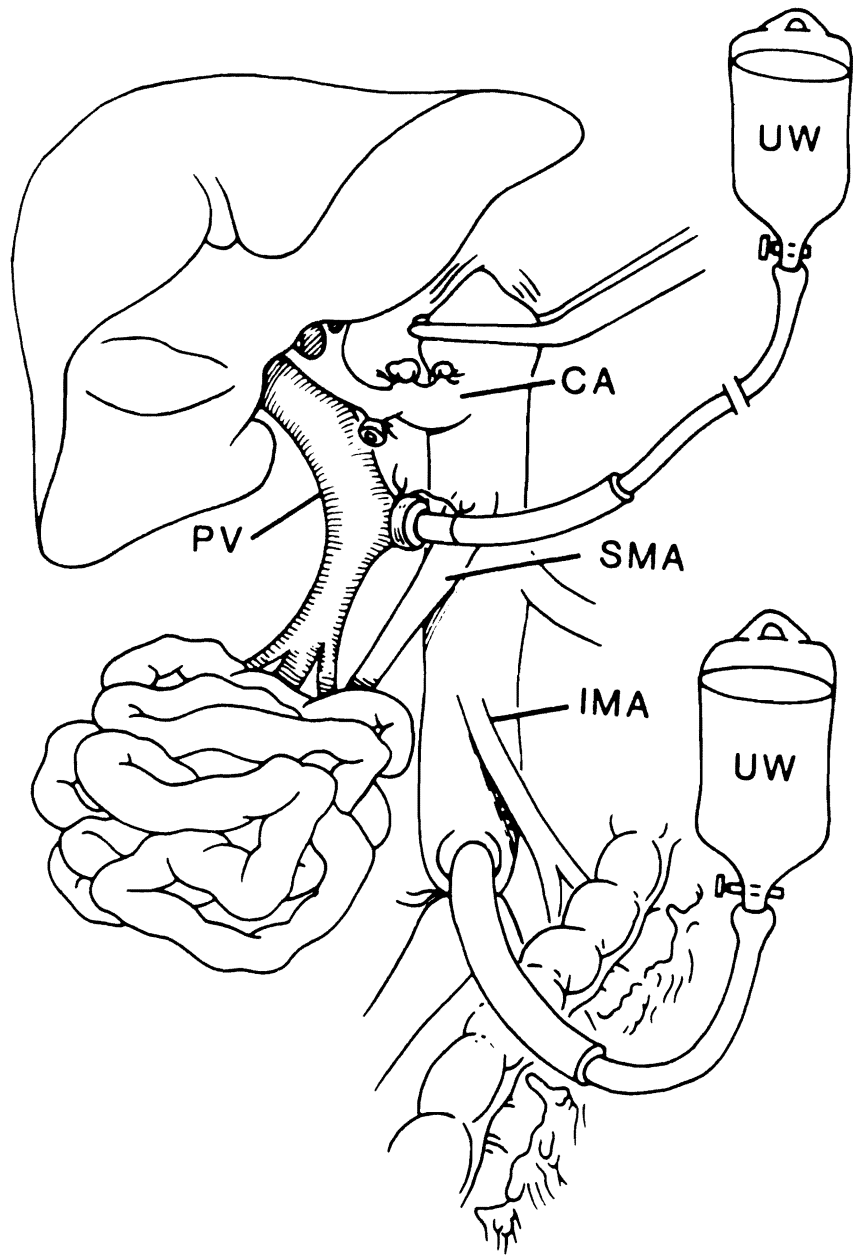


Figure 11-6. In situ perfusion with UW solution through both abdominal aorta and portal vein. In multivisceral procurement the graft is perfused only through the abdominal aorta. UW = University of Wisconsin solution; CA = celiac artery; SMA = superior mesenteric artery; IMA = inferior mesenteric artery; PV = portal vein.

the duodenum with the attached proximal jejunal segment are further mobilized and dissected from the root of the mesenterium by dividing the small numerous branches between the superior mesenteric vessels and the duodenum as well as the pancreas.

In a nonpancreatic donor, the portal and superior mesenteric veins are exposed by transecting the pylorus and the neck of the pancreas. After the anterior surface of the portal and superior mesenteric veins are exposed, the lateral and posterior walls are dissected from the pancreas and duodenum by interrupting the pancreatic and duodenal tributaries. Meanwhile, a short segment of the splenic vein at the confluence is dissected and encircled for future cannulation. The infrarenal aorta is dissected toward the bifurcation of the common iliac arteries. The distal abdominal aorta and the splenic vein are cannulated after systemic heparinization of the donor. After the supraceliac or thoracic aorta is cross clamped, the abdominal aorta and portal vein are individually perfused with an adjusted volume of UW solution (Fig. 11-6). To separate the liver from the intestine, the portal vein is transected above the confluence of the superior mesenteric and splenic veins. The liver graft is then retrieved using the standard technique (26,27). For the intestinal graft, a Carrel patch is fashioned containing the origin of the superior mesenteric artery on the aorta. The intestine is then removed and immersed in the UW solution. In cases that require a vascular conduit, the arterial or venous grafts, or both, are anastomosed to the graft superior mesenteric artery and vein on the back table.

In a pancreatic donor, both the superior mesenteric artery and vein are completely dissected and isolated just above the origin of the middle colic vessels. After perfusion, the superior mesenteric vessels and inferior mesenteric artery are divided, and the intestinal graft is removed. The organs are then placed immediately in a plastic bag containing cold UW solution, packed in an ice container, and transferred to the recipient hospital.

VARIATION TO INCLUDE THE COLON

Additional colon retrieval is possible depending on the recipient requirements. This variation is also applied to combined liver and intestinal, or multivisceral procurement. In addition to the cecum, ascending colon, and mesenterium, descending colon is mobilized from the retroperitoneum. Before cross clamp, the origin of the inferior mesenteric artery is carefully identified. The sigmoid colon is then transected after mobilization by dissecting the mesocolon down to the rectosigmoid junction. After cross clamp, the inferior mesenteric artery is preserved and procured using the Carrel patch technique.

Intestine Combined with Liver

After the abdominal cavity is entered, the liver is mobilized by dividing its ligaments (Fig. 11-7). The gallbladder is incised following transection of the common bile duct, and the bile is washed out. The portal vein is exposed after dividing the right gastric and gastroduodenal arteries. The left gastric and splenic arteries are then identified and divided. The remaining steps of mobilizing and dissecting the intestinal portion of the graft are the same as those used to retrieve the isolated intestinal graft in a nonpancreatic donor. It is important to

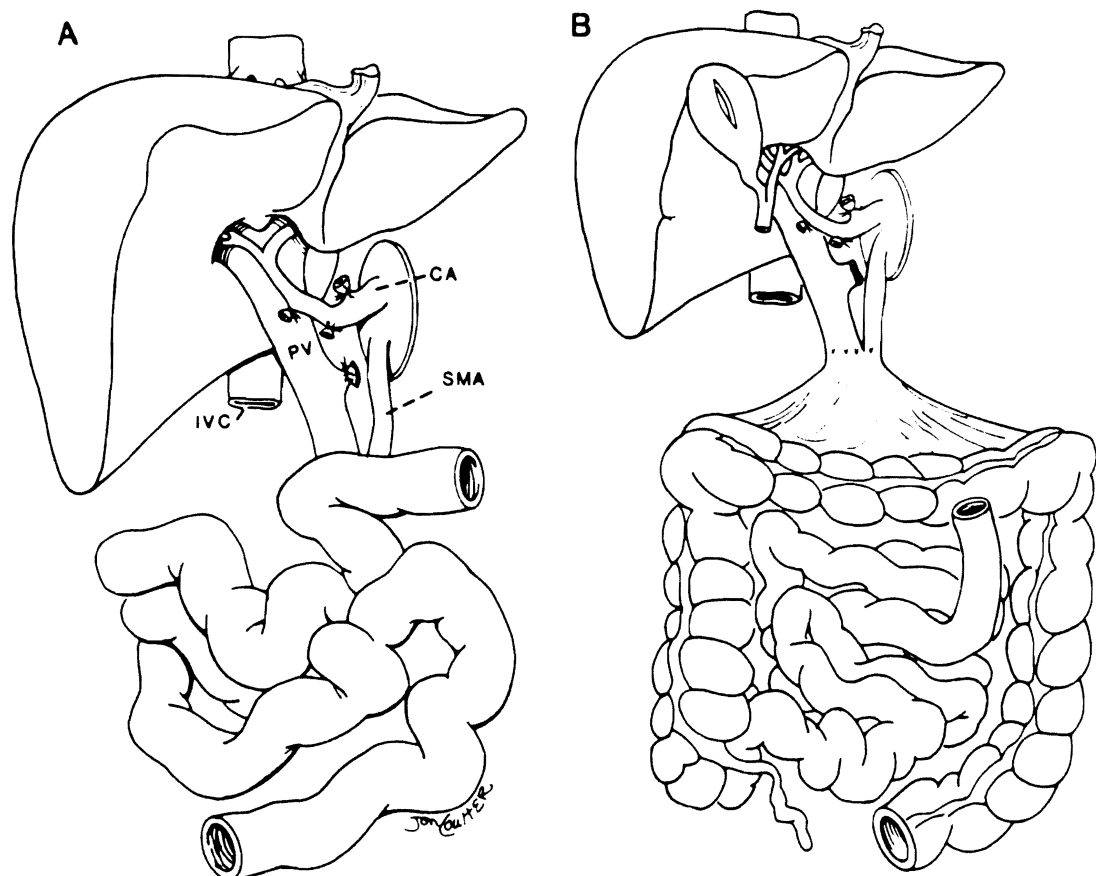


Figure 11-7. Combined liver and intestinal graft. A. Without colon. (Reproduced by permission from Todo S, Tzakis AG, Abu-Elmagd K, et al. Intestinal transplantation in composite visceral grafts or alone. *Ann Surg* 1992;216:223-234.) B. With colon. (Reproduced by permission from Furukawa H, Abu-Elmagd K, Reyes J. Technical aspects of intestinal transplantation. In: Braverman MH, Tawe RL, eds. *Surgical technology international 2*. San Francisco: Surgical Technology International, 1993:165-170.) Carrel patch including celiac axis (CA) and superior mesenteric artery (SMA). Note the continuity of donor portal vein. IVC = inferior vena cava.

emphasize that the pancreas must be sacrificed in order to procure the liver and intestinal grafts en bloc. Complete dissection and separation of the superior mesenteric vessels from the duodenum and pancreas are carried out on the back table.

After cross clamping, both the infrarenal aorta and the portal vein are individually perfused with the adjusted volume of UW solution. A Carrel patch is fashioned, containing the origins of both the celiac axis and superior mesenteric artery on the aorta. The infrahepatic vena cava is transected above the renal veins. The organs are removed en bloc and placed in the standard plastic bag containing cold UW solution, and packed in the ice container for transportation.

On the back table, the suprahepatic and infrahepatic vena cava are fashioned in the same way as for liver transplantation. After proper orientation of the vascular structures of the graft, both the pancreatic head and duodenum are carefully dissected and separated from the graft. After both the celiac axis and the superior mesenteric artery are dissected down to the origin of the middle colic artery, the Carrel patch is anastomosed to a suitable aortic graft as a common vascular conduit (see Fig. 11-3).

Intestine as Part of Multivisceral Graft

Retrieval of the multivisceral graft, which includes the stomach, duodenum, pancreas, intestine, and liver, is a unique technical procedure (Fig. 11-8). The greater gastric curvature is devascularized with preservation of the gastroepiploic arch. The short gastric vessels are ligated and interrupted, and the greater omentum is resected. The remaining steps of mobilizing and dissecting the intestinal portion of the graft are the same as those used to retrieve the isolated intestinal graft in a non-pancreatic donor. Splenectomy is done either in situ or on the back table. In situ splenectomy is performed after complete mobilization of both the spleen and pancreas from the retroperitoneal structures with interruption of the splenocolic ligament. Meticulous dissection of the splenic hilus and individual ligation of the splenic vessels is mandatory to avoid injury of the pancreatic tail. The esophagogastric junction is transected using the stapler technique. The multivisceral graft is perfused *only* through the distal abdominal aorta with one to two liters of UW solution. The back table procedure, with dissection of suprahepatic and infrahepatic vena cava, is the same as in liver transplantation. The celiac axis and the root of the superior mesenteric artery are dissected and isolated while the surrounding lymph nodes, ganglion, and nerves are removed. The Carrel patch is anastomosed to a suitable aortic graft as a common vascular conduit. Pyloroplasty or pyloromyotomy is performed either on the back table or after implantation of the graft.

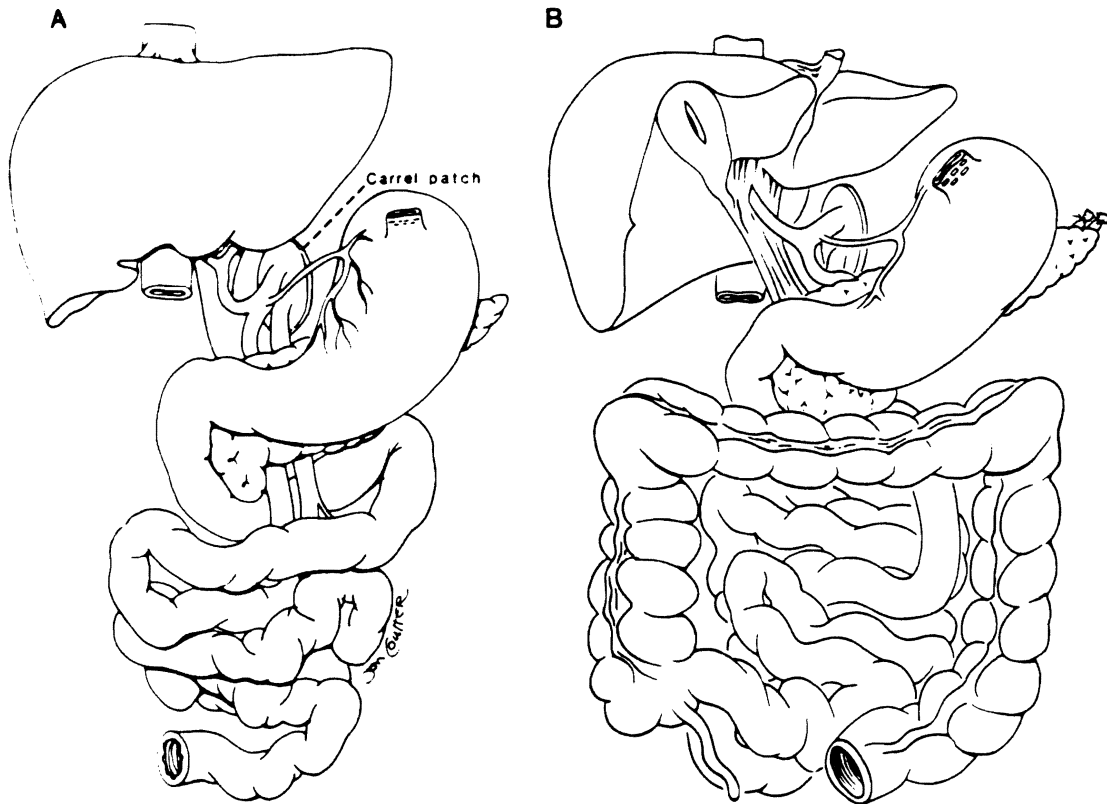


Figure 11-8. Multivisceral graft. A. Without colon. (Reproduced by permission from Todo S, Tzakis AG, Abu-Elmagd K, et al. Intestinal transplantation in composite visceral grafts or alone. *Ann Surg* 1992;216:223-234.) B. With colon. (Reproduced by permission from Furukawa H, Abu-Elmagd K, Reyes J. Technical aspects of intestinal transplantation. In Braverman MH, Tawe RL, eds. *Surgical technology international 2*. San Francisco: Surgical Technology International, 1993:165-170.) Carrel patch including celiac axis (CA) and superior mesenteric artery (SMA). Splenectomy was performed during donor operation or on the back table.

VARIATION OF THE SURGICAL TECHNIQUES

Our cumulative surgical experience with intestinal transplantation dictated subsequent modification of donor operative techniques.

With increasing demands for additional organ replacement at the time of transplantation for some recipients, the multivisceral retrieval has been adopted for cases with extended thrombosis of the splanchnic vessels, disease with uncertain extension (active Crohn's disease, pseudo-obstruction, and total aganglionosis), marginal liver function, and history of pancreatitis. These patients might require additional

organs, such as the liver, pancreas, and stomach, in addition to the expected organ requirement. The graft is then tailored on the back table according to the organs that it will replace (28) (Fig. 11-9).

The feasibility of the vascular and enteric anastomoses with preservation of the ileocecal valve by transplanting part of the donor colon has been proved. A pullthrough operation was performed in two pediatric recipients to preserve the anorectal sphincters. Retrieval of the entire colon down to the rectosigmoid is required with preservation of its marginal blood supply including the inferior mesenteric arcade (29).

However, recent analysis shows that the inclusion of the colon in intestinal grafts worsens graft outcome. This poor outcome is due to graft rejection occurring in the early postoperative period. These findings suggest that only small intestine or a short segment of the colon preserving the ileocecal valve should be included in the graft (30).

In one of our multivisceral recipients, the native liver was preserved and the retrieved liver was separated from the multivisceral graft and given to a second recipient. Technically, the liver is separated from the graft by dissecting and transecting the common hepatic artery below the origin of the gastroduodenal artery and the portal vein above the confluence of the splenic and superior mesenteric veins on the back table.

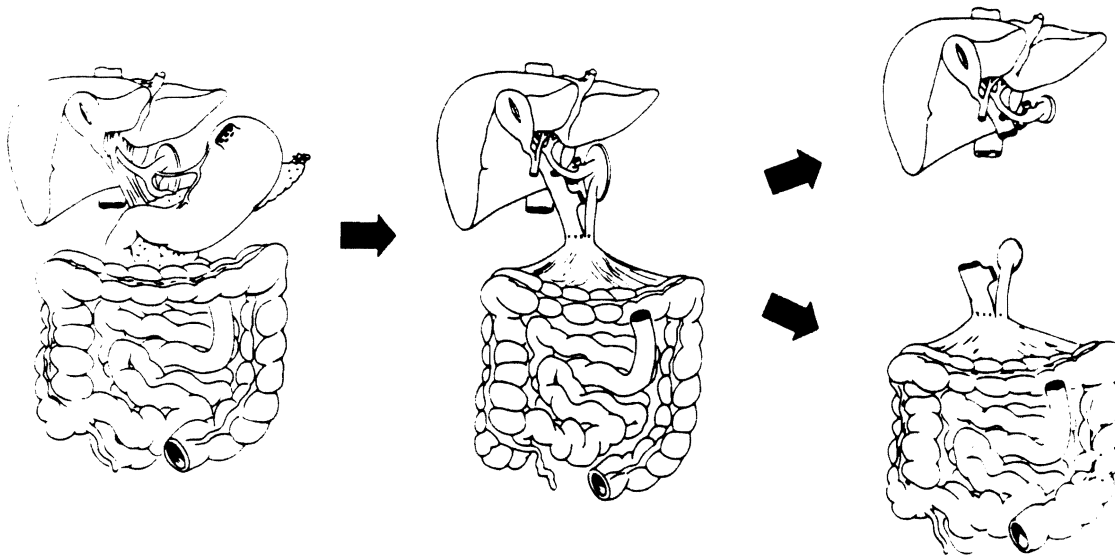


Figure 11-9. Multivisceral graft (*left*) can be transformed to combined liver and intestinal graft (*middle*) by removing stomach, duodenum, and pancreas. Liver and intestinal graft can be divided to liver and isolated intestine (*right*)

INTESTINAL PRESERVATION

Maintaining the morphologic and functional integrity of the intestinal grafts during the time interval from cross clamp to postreperfusion period is essential for intestinal preservation. University of Wisconsin solution has been applied to successful clinical intestinal transplantation. Although this solution has been proven to allow extended cold storage of the liver (31–33), pancreas (34), and kidney (35) in both animals and humans, the limit of intestinal storage with UW solution has not yet been determined. Therefore, the intestine is currently transplanted as soon as possible after retrieval. If a preservation method would allow the intestinal graft to function after an ischemia time of 12 to 24 hours, more organs would be available from more distant cities, and unnecessarily rushed donor and recipient surgery could be avoided. Close scrutiny of the graft would even be possible before the recipient surgery was begun.

In his early experiments, Lillihei first documented the safe limit of a complete *in vivo* interruption of intestinal circulation in dogs (36). The small bowel tolerates 2 hours of total ischemia if the bowel is allowed to cool to room temperature (25°–28°C). If the bowel is cooled to 5°C, it is safe to interrupt its circulation completely for at least 5 hours. Addition of chlorpromazine to the storage solution or hyperbaric oxygen, or both, allows successful preservation at 2° to 4°C for 24 and 48 hours, respectively (37,38). The development of continuous machine perfusion permits preservation of intestinal grafts for 18 hours *in vitro* (39). Perfusion preservation with Collins solution, dog plasma, or human plasmanate is used in autotransplantation in dogs and allows preservation for 24 hours (40,41). However, since both hyperbaric oxygen and continuous machine perfusion are very complicated for clinical usage, simple cold storage is widely used along with the improvement of preservation solutions. Various preservation solutions have been tested, comparing survival, histology, mucosal enzyme activity, mucosal high-energy phosphate, and motility function in animals. Preservation of the small intestinal grafts with UW solution for 12 to 48 hours allows 67% to 100% survival in rats (42–44). Although some discrepancies exist with high-energy phosphate level of the mucosa in the nonsurvival studies using UW solution (45,46), UW solution seems to be superior in survival as well as motility function (42).

The techniques of perfusion and reperfusion of the intestinal grafts represent an important factor in intestinal preservation. The addition of luminal flushing to the standard vascular flushing of intestinal grafts improves the survival of dogs receiving 24-hour preserved small bowel grafts from 0 to 80% (47). A beneficial effect of the vascular washout (4°C saline) and topical rewarming at the time of reperfusion has been studied. Rats that received 12-hour preserved small intestine under extracellular fluid without vascular washout, with topical rewarming,

have significantly better survival (67%) than the other groups (17%–33%) (44).

In clinical intestinal transplantation in Pittsburgh, UW solution has been used for all grafts except the isolated intestinal graft, which was excised and simply immersed in cold lactated Ringer's solution. The cold ischemia time for all grafts ranged from 2.8 to 12.1 hours with a mean of 7.6 hours. These relatively short cold ischemia times reflect our adopted policy by utilizing local donors, and coordinating the timing for the donor and recipient operation.

Ischemic and preservation injury are clinically and histologically documented in most grafts (48). Although none of the intestinal grafts have been lost from ischemic and preservation injury, the following two incidents might be related to the same mechanism. In one of the multivisceral grafts, the small intestine had multiple perforations with intramucosal to transmural coagulative necrosis in the antimesenteric portion of the small intestinal wall 10 to 25 days after transplantation, which required multiple intestinal resections. In one of the combined liver and intestinal grafts, a solitary perforation was found at the splenic flexure of the transverse colon in the antimesenteric border 15 days after transplantation. The loop colostomy was performed, and was later closed. Both grafts had relatively long cold ischemia time, 8.2 and 11.4 hours, respectively. Ischemia from perioperative phenylephrine hydrochloride infusion in the first case, and prolonged cardiopulmonary resuscitation before procurement in the second case, were suspected as causes.

CURRENT RESULTS

Of the 62 recipients, 31 (50%) are currently alive 9 to 55 months after intestinal transplantation. The main causes of death are rejection, infection, and posttransplant lymphoproliferative disorder (PTLD). Of the 31 current survivors, 25 (80%) patients are free of TPN and enjoying an unrestricted oral diet (Table 11-2).

Table 11-2. Current Status of Intestinal Transplantation

Type of Graft	Median Follow-up (mo)	Patient Survival	Graft Survival	Patients at Home	Patients TPN Free
Isolated intestine	19 (0.7–40)	12/22 (54.5%)	8/24 (33.3%)	11/12	8/12
Liver and intestine	21 (0.7–55)	14/29 (48.3%)	14/31 (45.2%)	13/14	13/14
Multivisceral	21 (1.6–40)	5/11 (45.5%)	5/11 (45.5%)	5/5	4/5

Until recently, for three decades, the intestine was recognized as a "forbidden organ" for transplantation because of poor clinical results. After introduction of FK 506, clinical intestinal transplantation was proven as a feasible procedure for various types of irreversible intestinal failure. However, current patients and graft survivals in intestinal transplantation have declined from overwhelming rejection and infection even 2 to 3 years after transplantation. New strategies will be required for immunosuppression and infection control to achieve more practicality in intestinal transplantation.

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