7

Intestinal and Multivisceral Transplantation

Thomas M. Fishbein and Cal S. Matsumoto

Intestinal transplantation has evolved from an experimental procedure with limited success to standard of care for patients with intestinal and parenteral nutrition failure, achieving outcomes commensurate with other solid-organ transplants.[1,2] Paramount to achieving the success of intestinal and multivisceral organ transplant procedures has been the refinement of donor organ procurement and transplantation techniques.[3] Early graft failures and deaths due to technical and donor-related complications have been minimized using the techniques described here, leaving the current challenge largely of optimizing immunologic and infection management strategies.[4,5] Techniques depicted here are those of choice in our experience, while mention is made of alternative techniques that may be preferred by others. Because patients requiring intestinal transplantation often present with multiple organ failures and require multiorgan transplantation, modification of these techniques may be required on an individual basis. Addition of renal allotransplantation, inclusion of the colon in a small-bowel or multivisceral graft, and modified multivisceral transplantation with preservation of the native liver are some of the common modifications. Intimate description of all possible techniques is beyond the scope of the chapter.

The three most common types of allografts involving the small intestine are isolated intestinal transplantation, combined liver–small bowel transplantation, and multivisceral transplantation. These are described in turn, detailing our commonly preferred methods for both donor and recipient surgical techniques.

Isolated Intestine Transplant

a) Donor Procedure

1. The standard sternum to pubis incision is made, taking care not to injure the bowel upon entering the abdomen. On many occasions, due to either the nature of injury or the preoperative state of the donor, the intestine may be dilated or edematous and may closely abut the abdominal wall. A nasogastric tube should decompress the stomach and upper gastrointestinal tract. We additionally prefer to decontaminate the allograft through instillation of antibiotics into the lumen through the indwelling nasogastric tube. Immediately upon entering the abdomen, another dose of selective gut decontaminant may be administered, and passed through the pylorus into the small intestinal graft.

A broad Kocher and Cattell maneuver are each performed, and the aorta and inferior vena cava are exposed behind the intestinal mesentery up to the superior mesenteric artery (Figure 7.1).

2. The ligament of Treitz is broadly mobilized from the retroperitoneum and aorta, mobilizing the distal duodenum and proximal jejunum. The abdominal aorta is encircled distally for eventual aortic cannulation and flush. The gastrocolic omentum is

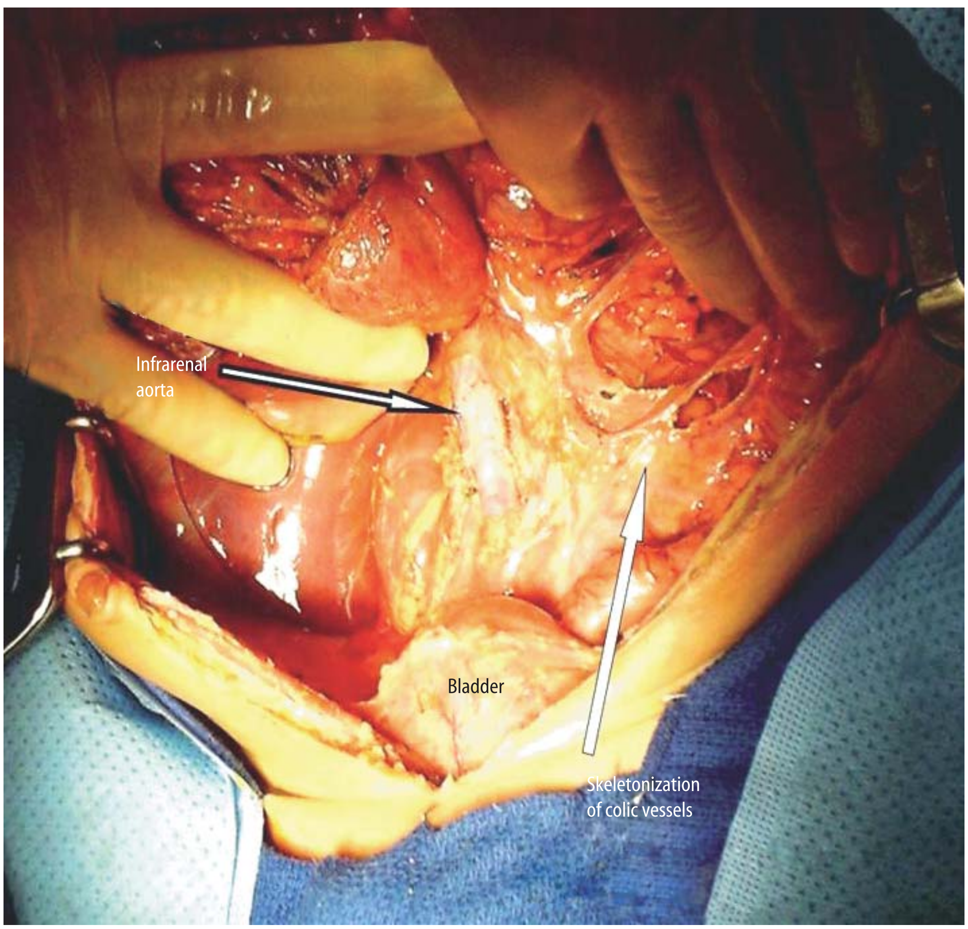

Figure 7.1

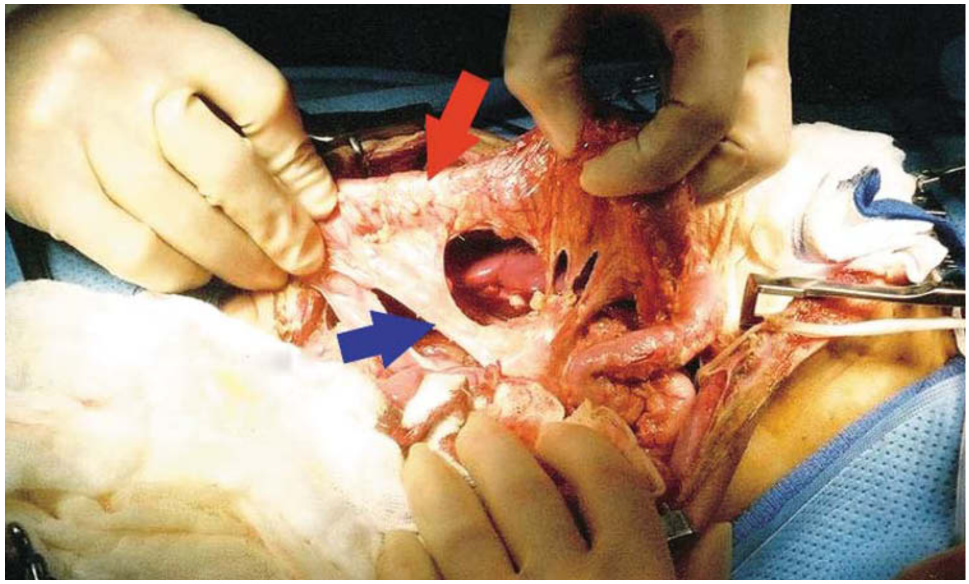

Figure 7.2

divided, and the left colon is mobilized (red arrow) (Figure 7.2). The mesentery of the colon is then dissected, exposing right, middle and left colic vessels. Exposure of the colic vessels (blue arrow) facilitates rapid removal of the colon immediately prior to heparinization and cannulation.

3. A medial visceral rotation mobilizes the tail of the pancreas (yellow arrow) with the spleen (blue arrow), exposing the left side of the aorta and origin of the mesenteric vessels (Figure 7.3). As with standard pancreas procurement, the pylorus is transected with a linear stapler, leaving sufficient length to invert the staple line with another layer of suture. The stomach is rotated laterally out of the abdominal field after ligation of the left gastric artery, separation of the stomach from the greater omentum, and division of the short gastric vessels to the spleen. The use of the inferior mesenteric vein (IMV) for flush during intestinal procurement is discouraged, as high flow and pressure in the IMV flush may decrease intestinal outflow through the superior mesenteric vein. In multivisceral graft procurement, care must be taken to avoid injury to the left gastric artery, while attachments of the stomach to the colon via the greater omentum are still divided.

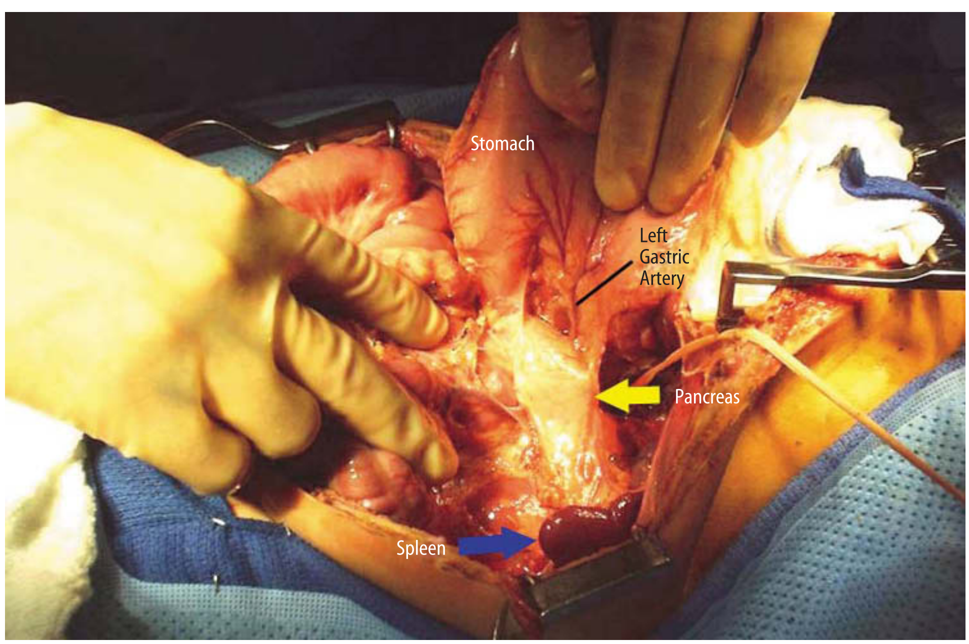

Figure 7.3

4. The liver graft dissection is performed in the standard manner, previously described in this atlas. Once there is satisfactory dissection by all participating procurement teams (heart, lung, liver, pancreas), and *prior* to administration of systemic anticoagulants, the small intestine luminal contents are manually propulsed in an antegrade fashion from the pylorus to the ileocecal valve. Since the bowel is a hollow viscus, air left in the organ may allow more rapid rewarming during cold preservation. Care must be taken while manually advancing luminal contents to prevent serosal injury of the sometimes fragile intestine. This maneuver decompresses the small intestine of both air and liquids and advances the luminal contents into the colon, allowing the ileocecal valve to prevent reflux. This should be the final maneuver performed prior to heparinization and aortic cannulation.

Once the small intestine is decompressed, the bowel is transected at the distal ileum and sigmoid. The colonic mesenteric vessels (blue arrow), which had been previously dissected, are ligated and transected, and the colon is rapidly removed from the cadaver (Figure 7.4). Vascular transection of the colon should be performed last to prevent drainage from an ischemic colon into the liver.

5. The donor cannulation, cross-clamping, flushing, thoracic venting, and topical cooling are performed in the standard manner. A laparotomy pad should protect the intestine from direct exposure to ice slush, as this may cause subserosal hematomas. Immediately prior to cross-clamping, the small intestine mesentery must be examined closely to ensure that there is no unintended volvulus. This will ensure adequate flush to both the intestine and liver portal system.

6. The liver is removed first, with transection of the portal vein at the level of the coronary vein, and transaction of the splenic artery. As in standard pancreas procurement, the splenic artery is always tagged with a fine suture for later identification. Our preference is to remove the pancreas and intestine graft en bloc, and separate the pancreas from the intestine at the backtable dissection. This technique ensures rapid organ retrieval from the cadaver after flush and allows for identification and ligation of individual proximal jejunal and duodenal mesenteric vessels in a controlled environment. Using this technique, both the pancreas and intestine grafts can be removed quickly from the cadaver by simply transecting the superior mesenteric artery at its aortic origin with or without a Carrel patch, as preferred by the pancreas surgeon.

7. Division of the base of the small intestine mesentery just below the inferior pancreaticoduodenal arcade may be performed in situ in a stable donor, although we usually avoid it due to prolongation of the donor procedure. In this case, the middle colic vessels

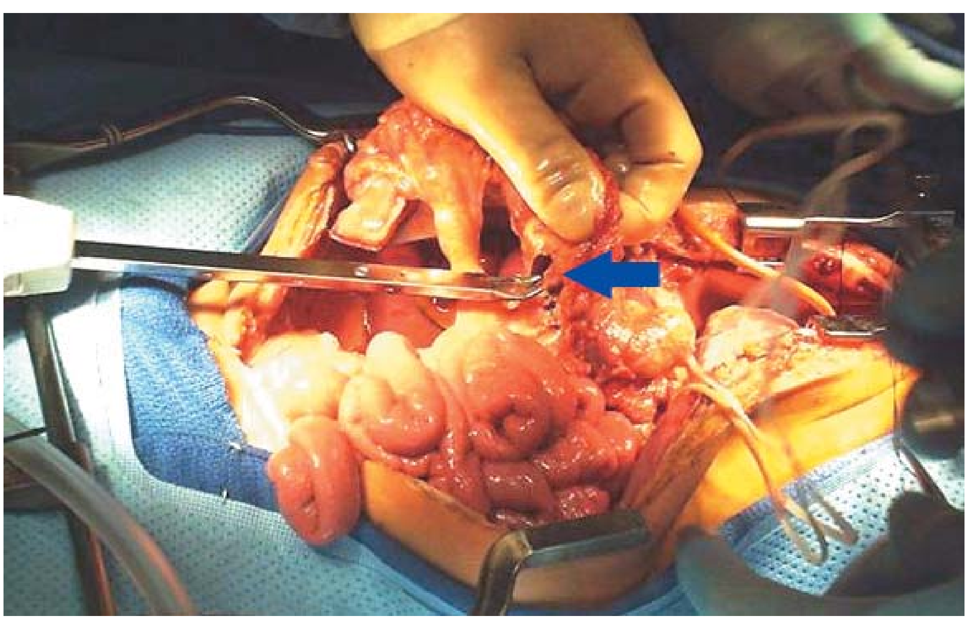

Figure 7.4

are divided, and the ligament of Treitz is widely mobilized from over the aorta and the inferior margin of the pancreas. The mesentery may be isolated by placing the entire small bowel over a moist laparotomy pad after removal of the colon. The jejunum may be divided with a stapling device approximately 10 cm distal to the ligament, and the superior mesenteric vein is identified laterally in the mesentery. Fine ligation of all lymphatic structures is performed, isolating the superior mesenteric vein and artery. The artery will usually give off a proximal jejunal arcade that requires division. Additionally, care must be taken not to injure the main jejunal vein draining the proximal allograft, as this usually runs posterior to the artery, joining the ileal vein to form the superior mesenteric high in the mesentery.

The isolated intestine donor operation historically precluded the use of the pancreas from the same donor; however, with close coordination between liver, pancreas, and intestinal procurement teams, successful procurement of all of these individual organs can be safely achieved.[10] The notable exception is the case in which the donor has a replaced right hepatic artery arising low on the superior mesenteric artery.

b) Back-Table Procedure

1. In the event that the pancreas is not being transplanted, the back-table dissection begins at the level of the portal vein. Stay sutures are placed on the portal vein and cuff of superior mesenteric artery (Figure 7.5)

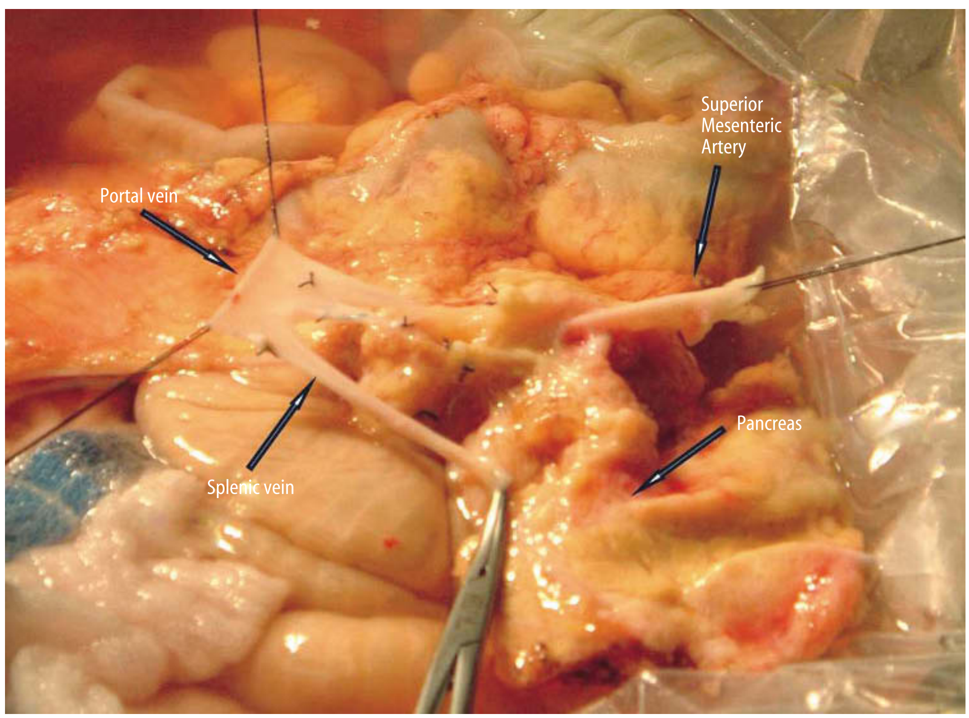

Figure 7.5

2. The portal vein dissection begins at the level of transection. Small pancreatic venous tributaries are identified and ligated. Care should be taken to preserve the splenic vein (Figure 7.6), as this provides a useful conduit for flush of preservation solution from the allograft at the time of reperfusion. (SMV, superior mesenteric vein; IMV, inferior mesenteric vein.)

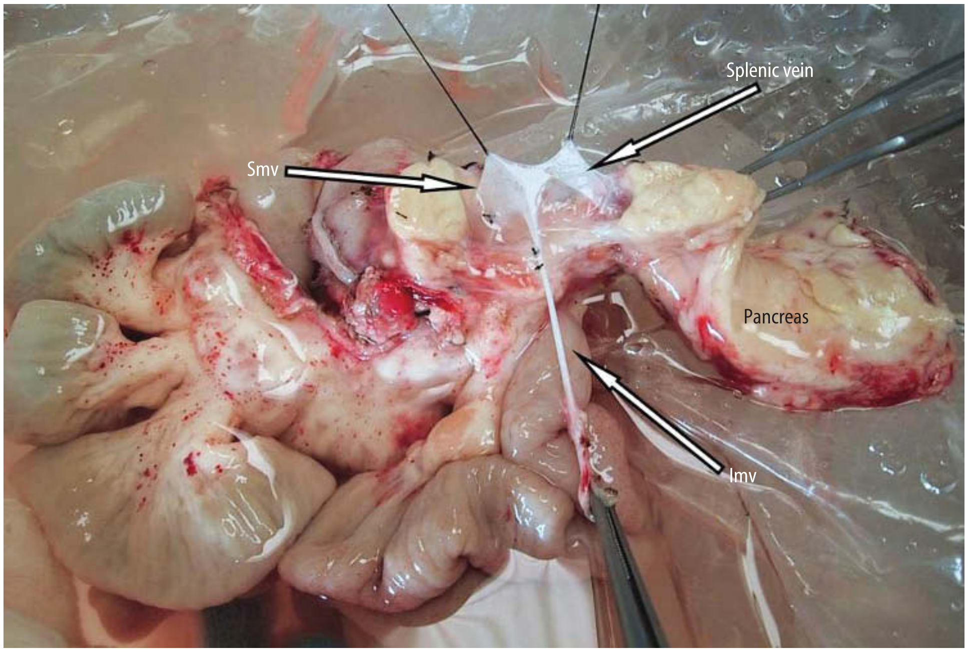

Figure 7.6

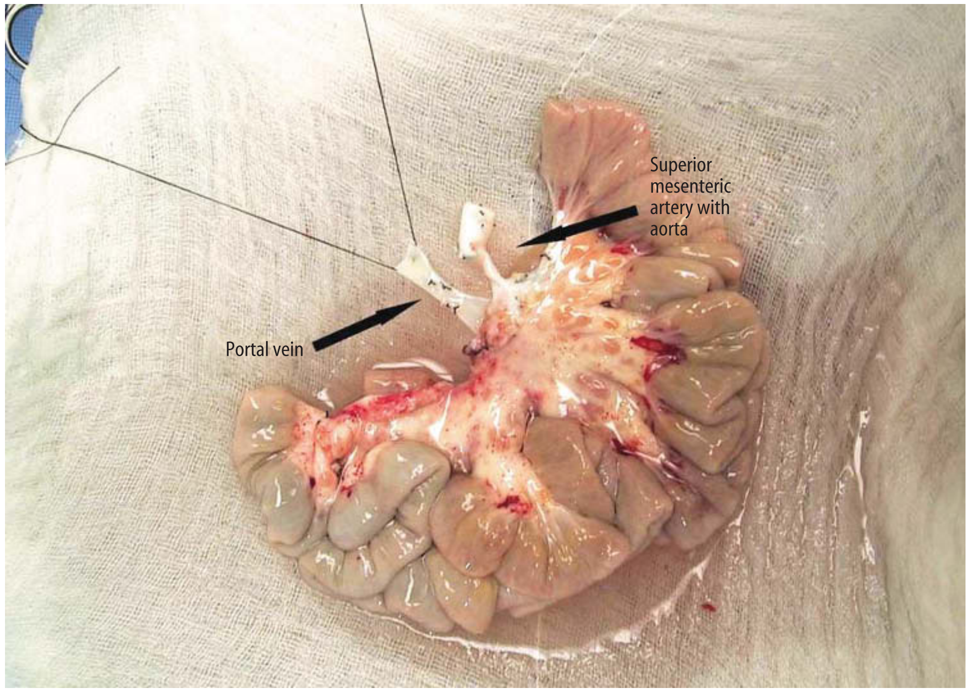

Figure 7.7

3. During separation of the intestinal graft from the pancreas, the jejunum is first transected, and the small and numerous jejunal mesenteric vessels are ligated. The finished graft should have a well-developed portal vein and superior mesenteric artery (SMA) for implantation (Figures 7.7 and 7.8).

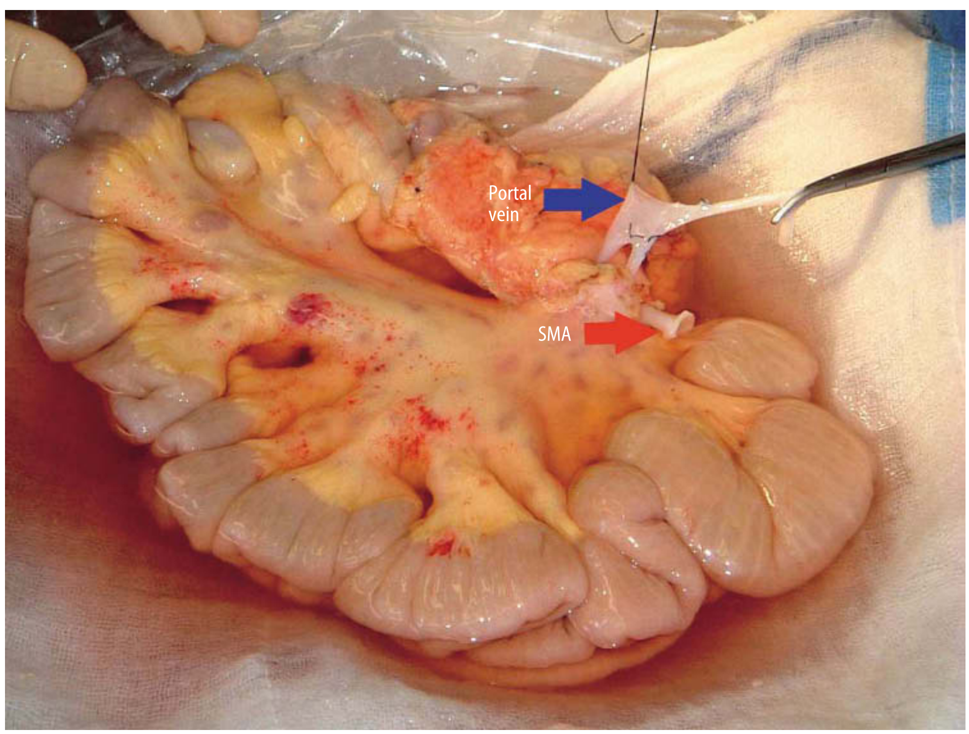

Figure 7.8

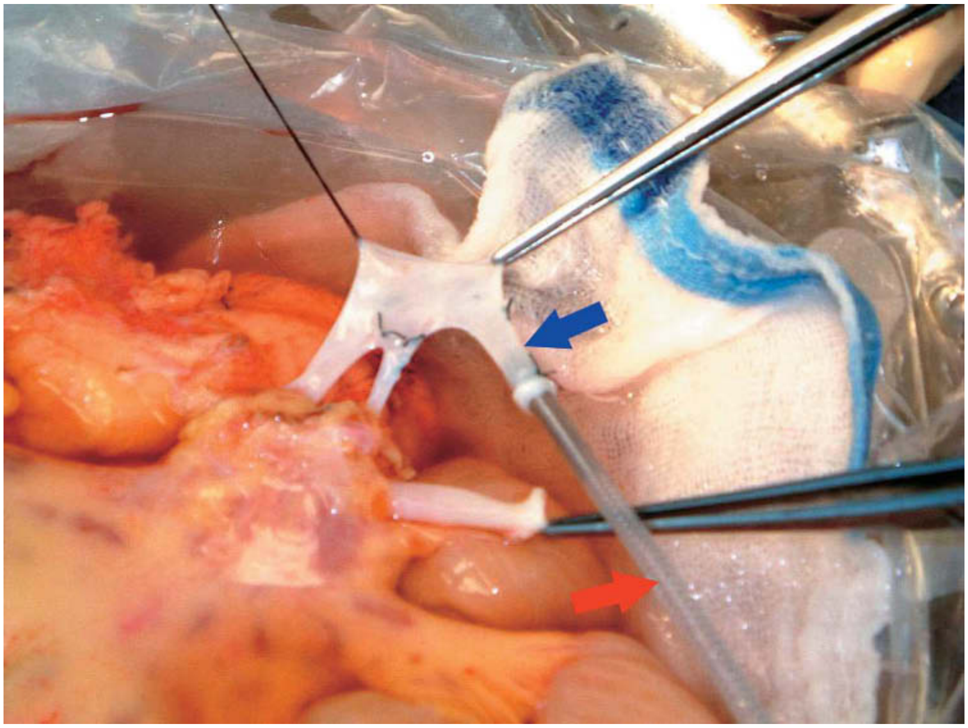

Figure 7.9

4. To facilitate the graft blood flush, a small cannula may be placed in the splenic vein (blue arrow) for ease in flush measurement. We prefer the use of a Sundt carotid endarterectomy shunt (red arrow), which is used to allow egress of the preservation solution prior to opening the venous clamp (Figure 7.9). The shunt is then removed, venous outflow clamp opened, and the splenic stump ligated.

5. If the pancreas is also to be transplanted as a whole-organ allograft, the mesentery is isolated upon a moist lap pad, and the mesenteric vessels are isolated below the inferior pancreaticoduodenal artery and vein, which provide necessary flow to the pancreas allograft. The middle colic vessels and first jejunal arcade usually must be ligated. Care should be taken not to injure the major jejunal vein, which usually courses behind the superior mesenteric artery to join the ileocolic vein high in the base of the small bowel mesentery. Small vascular clamps are placed on the superior mesenteric artery and vein after the flush, and these vessels are transected. The pancreatic side is individually oversewn with fine nonabsorbable suture and the bowel graft is again flushed on the back table. The pancreas and liver are then removed in the usual fashion. In the event that an aberrant right hepatic artery or aberrant common hepatic artery is encountered from the SMA, care must be taken to avoid injury to these vessels and the SMA must be divided distal to the origin of the aberrant vessel. When this is encountered, good-quality iliac or common femoral artery and vein extension grafts are required for implantation of the small bowel graft.

c) Recipient Procedure

Isolated intestinal transplantation is usually described by the technique of vascular reconstruction used for venous drainage, being either "mesenteric/portal" or "systemic." The surgical approach is determined by the underlying recipient intestinal disease, the health of the recipient's liver, and anatomic considerations that may influence the surgeon.[11] This is usually accomplished through a generous midline incision, although in babies less than 10 kg we sometimes prefer a transverse incision if one has previously been made.

We prefer to use mesenteric drainage for patients in whom the native small bowel is in place and will be removed at the time of transplantation. In cases of extreme short bowel, the superior mesenteric vessels carry little flow, are usually quite small and may not accommodate sufficient blood supply for the transplanted bowel; in these cases we usually prefer systemic vascular reconstruction.

Mesenteric Vascular Reconstruction

1. For candidates receiving an isolated intestinal allograft for functional disorders (infantile diarrhea or motility disorder), the native small bowel is usually in place. In this instance, blood flow through the mesenteric vessels is preserved, and they are of adequate caliber and quality for supply to the graft. Implantation, therefore, can be performed using these vessels prepared in the same manner as for isolated intestinal donor procurement. The jejunum is divided 10 to 20 cm distal to the ligament of Treitz, which is broadly mobilized. The arcade to the proximal jejunum is preserved. The recipient bowel is suspended by the root of the mesentery after disconnection at the proximal jejunum and colon, enabling fine dissection of the mesenteric root (yellow arrow), and isolation of the superior mesenteric artery and vein (Figure 7.10).

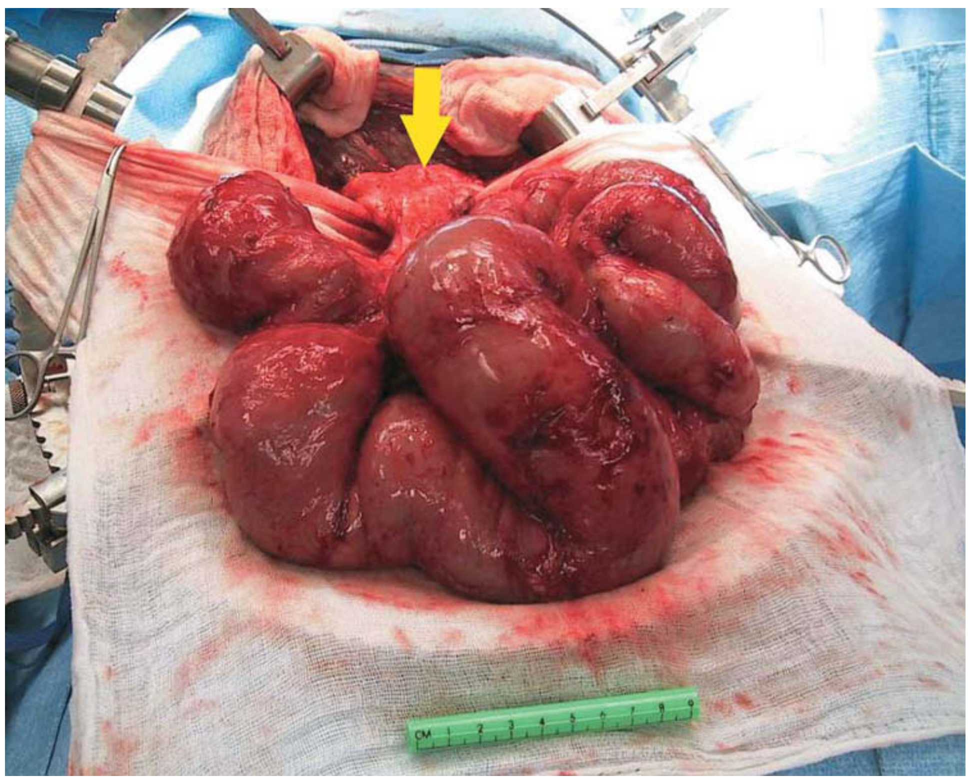

Figure 7.10

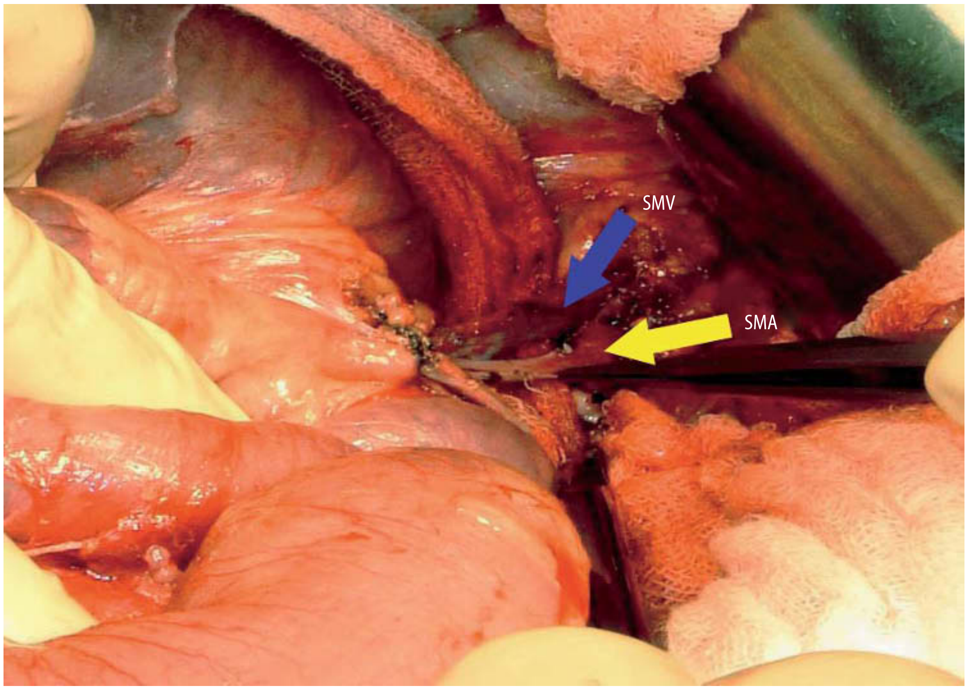

Figure 7.11

2. If the colon is intact, the middle colic vessels are ligated, the right and transverse colon mobilized, and the left transverse or descending colon divided. We always mobilize or remove the splenic flexure of the colon to assure endoscopic access to the ileum from below after closure of the stoma. The superior mesenteric vein (SMV, blue arrow) is located lateral to the superior mesenteric artery (SMA, yellow arrow) (Figure 7.11). Dissection of the base of the mesentery is undertaken to skeletonize these vessels. These tissues should all be ligated to avoid lymphatic or chylous ascites after transplantation.[12]

3. Small vascular clamps may be used to control the superior mesenteric artery (SMA) and vein (SMV), dividing them distally and preserving long cuffs for anastomosis (Figure 7.12). The proximal native jejunum should be preserved with the proximal jejunal arcade of the SMA for anastomosis to the donor jejunum.

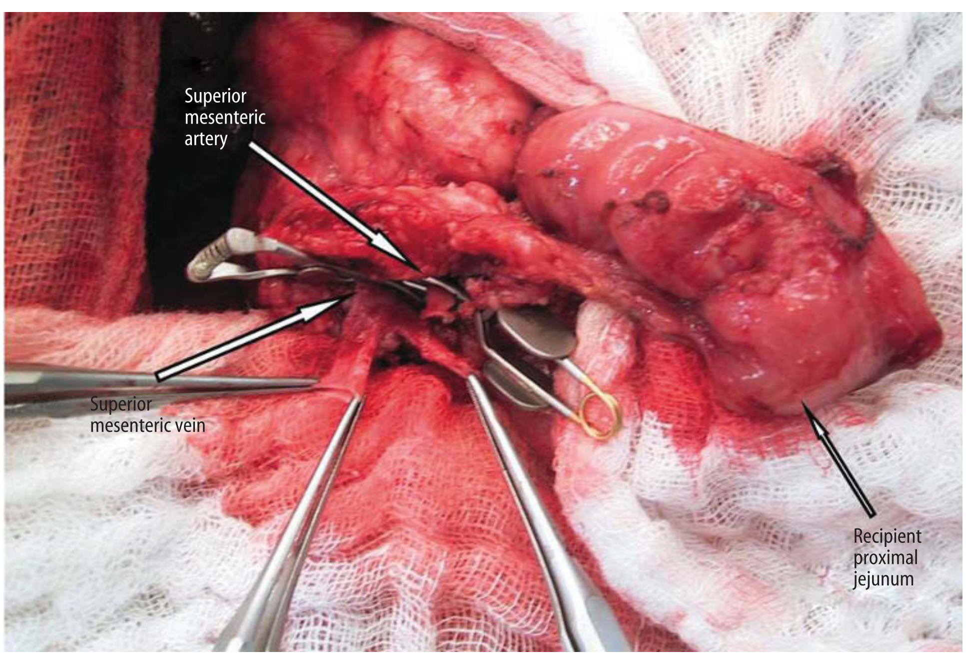

Figure 7.12

4. In some cases, placement of iliac or femoral arterial and venous conduits onto the graft vessels will be required (Figure 7.13). We have found that this facilitates transplantation when the pancreas has been procured for transplantation, as the graft mesenteric vessels will be shorter. They are best sewn in place prior to bringing the allograft into the field for implantation. Usually, either a short portion of external iliac or superficial femoral artery and vein are of appropriate caliber for anastomosis to the superior mesenteric vessels. The weight of the small bowel allograft may lead to tension over the duodenal sweep and predispose the graft to settle inferiorly toward the pelvis, so when using mesenteric reconstruction, attention should be paid to leaving generous length on the mesenteric vessels. Again, the main SMV should be used above the confluence of jejunal and ileal branches, which usually is quite close to the duodenal sweep.

In patients with short-bowel syndrome, the superior mesenteric vein sometimes cannot be exposed, as the base of the mesentery contracts after multiple prior resections. The venous anastomosis may be performed to the lateral wall of the portal vein in piggyback fashion, dissecting this vein free from the posterior porta hepatis, and placing an extension graft of iliac vein onto this in the end-to-side fashion.[13] We have only rarely employed this technique, and we discourage its routine use, as outcomes with systemic drainage are equivalent and accomplished with greater ease. However, it may be useful in cases of inferior vena cava thrombosis, where the alternative is placement of a venous extension graft on the suprarenal inferior vena cava, discussed below.

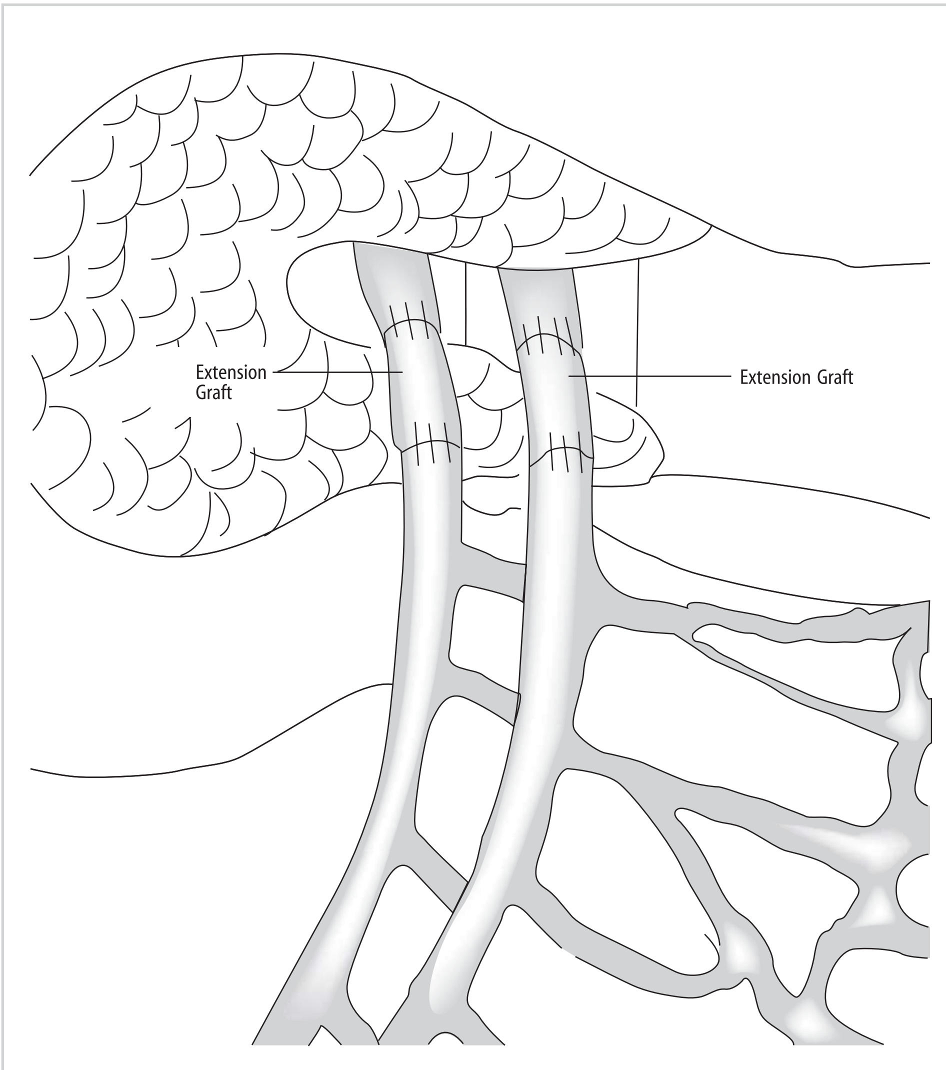

Figure 7.13

5. The bowel is then brought to the field after extension grafts are placed on the recipient vessels, and the base of the mesentery placed in a transverse plane aligning the donor and recipient vessels. The assistant is best positioned with a cold moist lap pad to both flatten the base of the mesentery as well as prevent bowel loops from entering the field, giving upward traction on the bowel allograft during anastomosis. The vessels are anastomosed end to end (Figure 7.14).

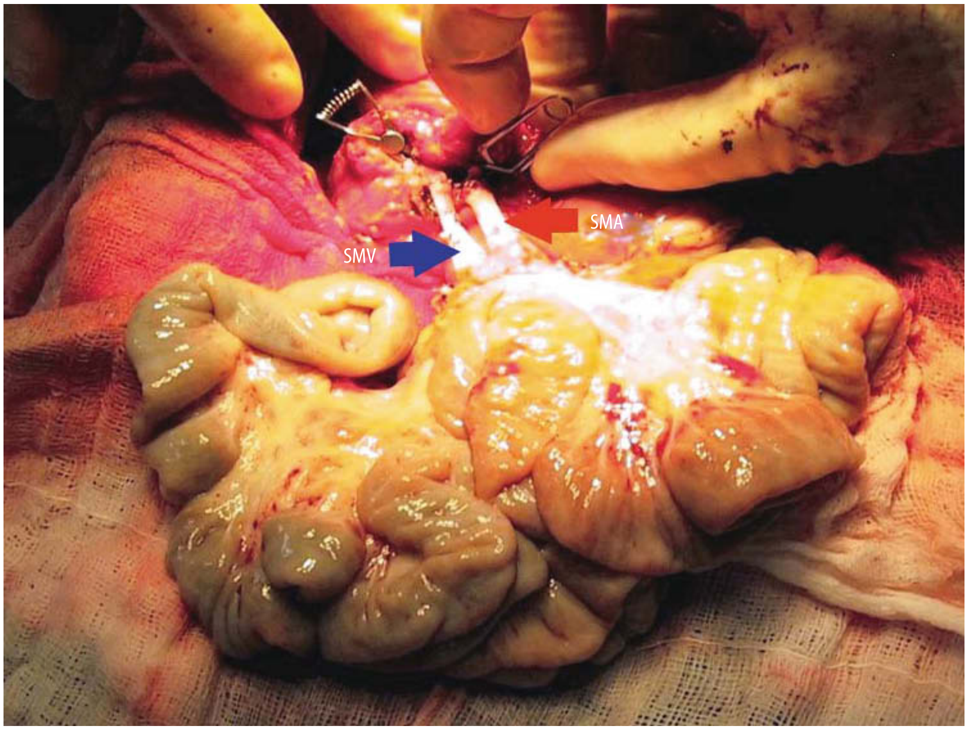

Figure 7.14

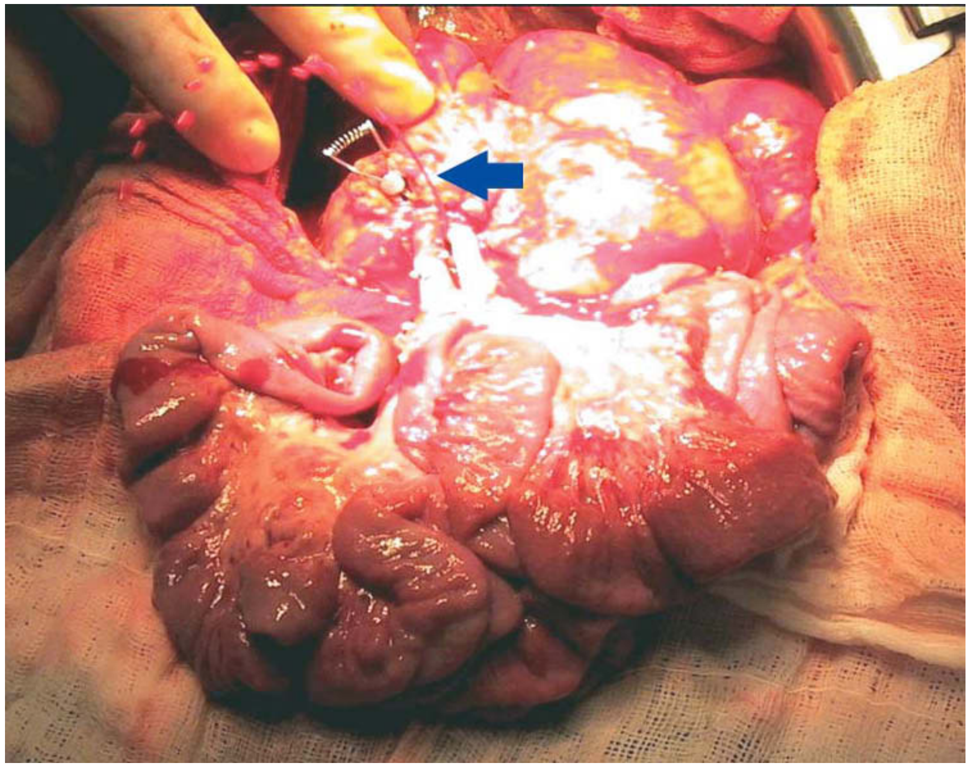

Figure 7.15

6. Reperfusion is then accomplished without heparinization. Upon reperfusion, blood and preservation solution is flushed out (blue arrow) prior to removal of the superior mesenteric vein clamp (Figure 7.15). This is facilitated by the previously placed cannula in the graft splenic vein, or through the superior mesenteric vein anastomosis.

7. The superior mesenteric vein clamp is then removed and venous return is reestablished (blue arrow, Figure 7.16).

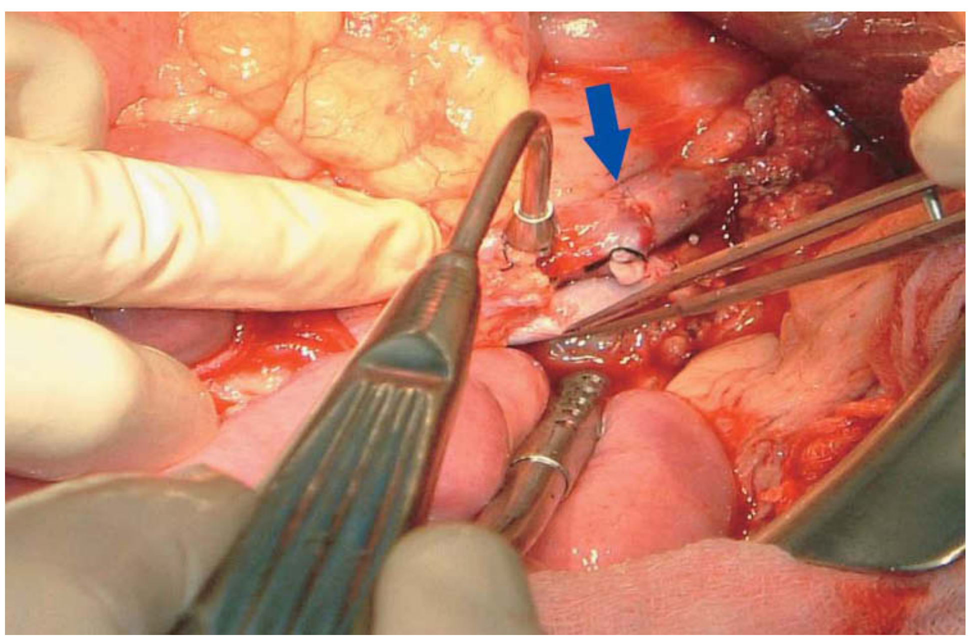

Figure 7.16

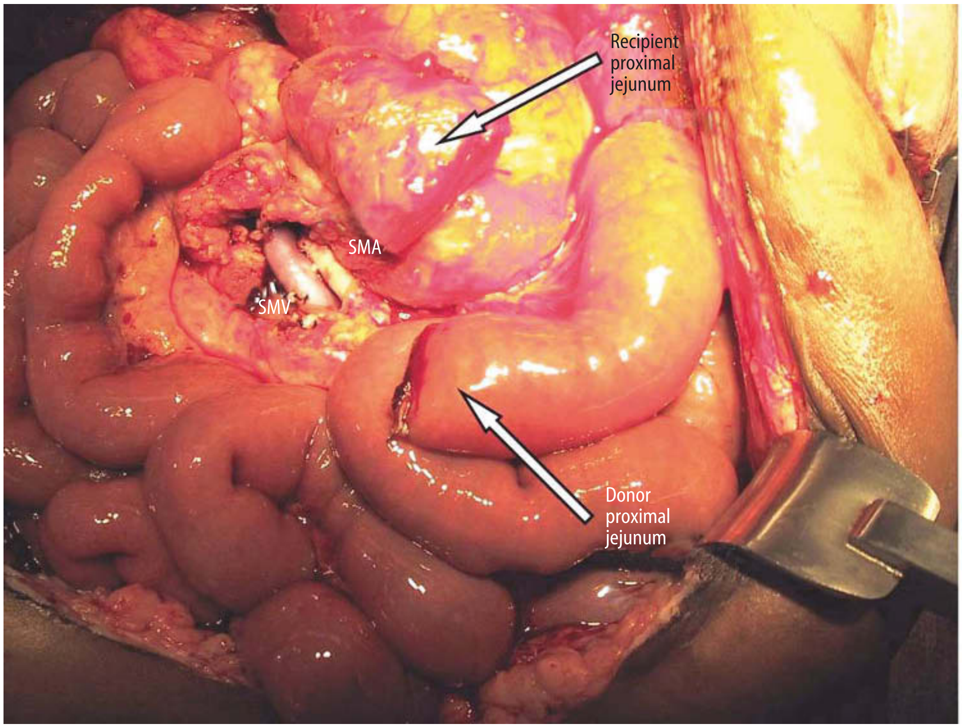

Figure 7.17

8. Fixation of the base of the mesentery transversely and without kinking of the vessels is critical to avoid volvulus or traction on the mesenteric vessels (Figure 7.17).

Systemic Vascular Reconstruction

This technique is more commonly employed for patients with short-bowel syndrome, particularly those with total or near-total loss of jejunum and ileum. In this disease state, the mesenteric vessels are often small in caliber, lacking good inflow. However, this is not always the case, and when a smaller donor with commensurately small vessels is being used, mesenteric drainage may still be used.

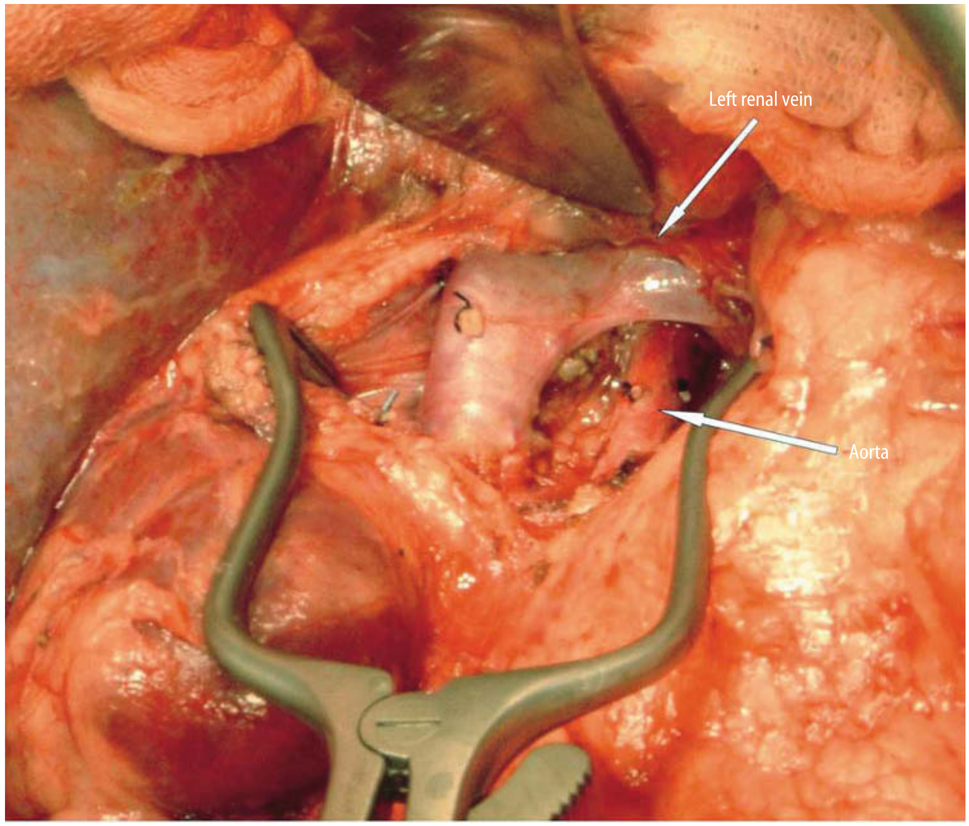

Figure 7.18

1. The recipient operation requires exposure of the infrarenal aorta for anastomosis of the arterial graft (Figure 7.18). The limits of dissection include the left renal vein above, and the inferior mesenteric artery below.

2. The inferior vena cava and aorta are clamped in preparation for systemic vascular anastomosis (Figure 7.19). The dissection may proceed below the inferior mesenteric artery, and this vessel controlled with a fine clip during anastomosis.

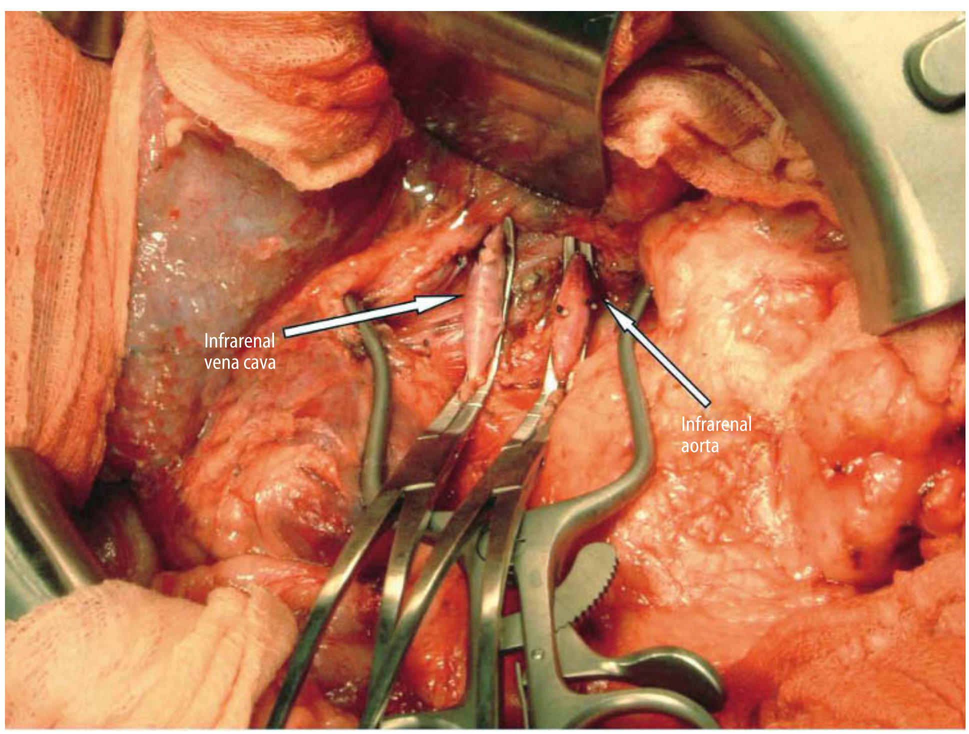

Figure 7.19

3. The arterial graft must be performed in a tension-free manner, as the weight of the bowel filled with secretions can lead to traction from the aorta to the pelvis or lead to decreased flow and thrombosis. The venous anastomosis is end-to-side to the anterior wall of the vena cava, as with a portocaval shunt (Figure 7.20). This is best accomplished after removal of an ellipse of vena cava to avoid narrowing. We prefer aortic inflow and caval drainage for patients who have demonstrated significant liver cholestasis, fibrosis, or ultrashort-bowel syndrome.[14] It is easy to accomplish, and in cases where intestinal transplantation is indicated due to reversible progressive liver disease, avoids drainage of the bowel graft into the possibly high-pressure portal circulation. The bowel graft is again oriented with the transverse mesentery parallel to the plane of the retroperitoneum, and sewn either directly to the aorta and vena cava, or as is our preference, to short extension grafts already placed to these vessels. Prior placement of extension grafts routinely makes implantation easy, not allowing loops of allograft small intestine to obscure the field of anastomosis. The mesentery is then fixed to the retroperitoneum to avoid internal hernia, volvulus, or traction on the vessels, care being taken to avoid the ureters. Systemic drainage has not been shown to yield inferior nutritional results, as some had initially predicted.[10,15,16]

4. Another technique is required when systemic drainage is being used in a patient with thrombosis of the inferior vena cava. This is not infrequently encountered, due to multiple femoral accesses for parenteral nutrition. In this case, ligation and division of a few low caudate veins allows placement of an extension graft of iliac or femoral vein on the suprarenal vena cava. This is accomplished with placement of a partially occluding clamp, removal of an ellipse of anterior caval wall, and placement of an extension graft. The graft is tunneled behind the mobilized duodenum and head of pancreas, to lie next to the infrarenal aortic anastomosis. We have found this easier to accomplish than piggyback drainage to the portal vein.

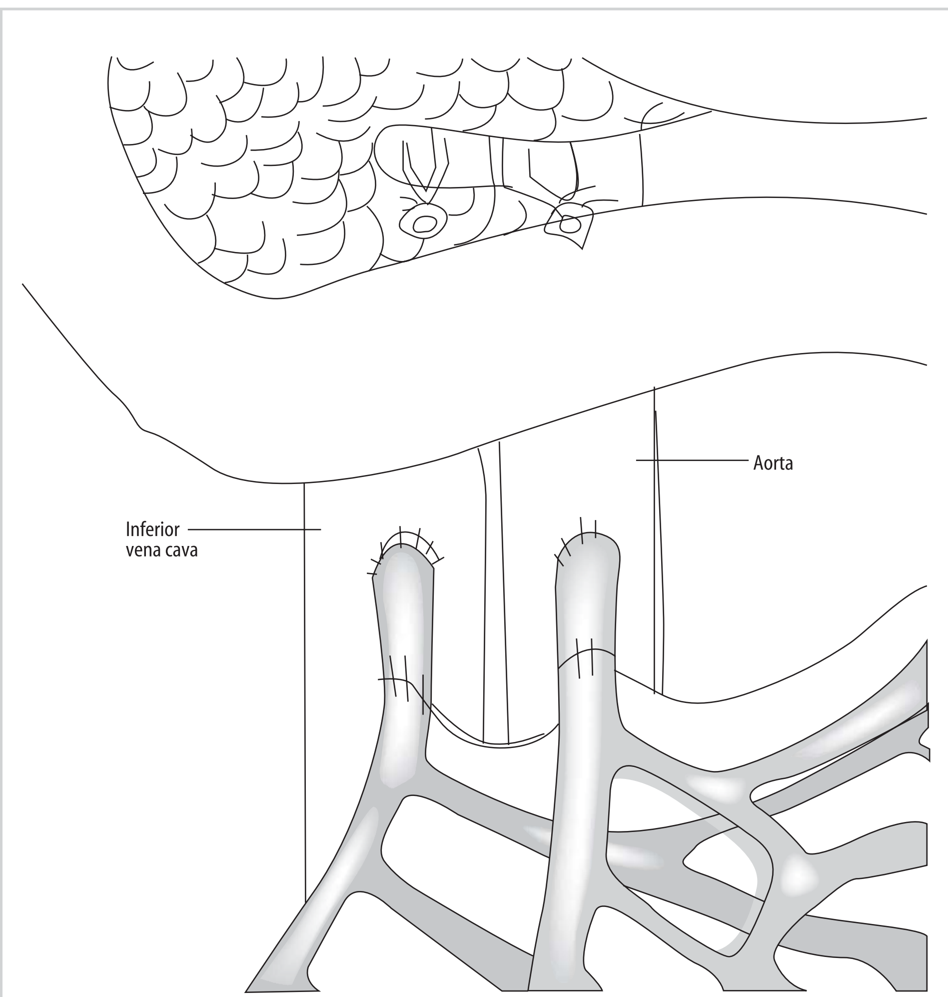

Figure 7.20

5. Enteral continuity is established proximally and distally in conjunction with an ileostomy, using either a loop-diverting ileostomy or a proximal ileocolostomy in a “chimney” fashion to provide access for surveillance allograft biopsy (Figure 7.21). These stomas also allow future ileostomy closure to be performed without a full laparotomy. Placement of tubes for intestinal access can be accomplished with gastric, jejunal, or combined tubes. These are placed to avoid prolonged need for nasogastric suction and facilitate early feeding.

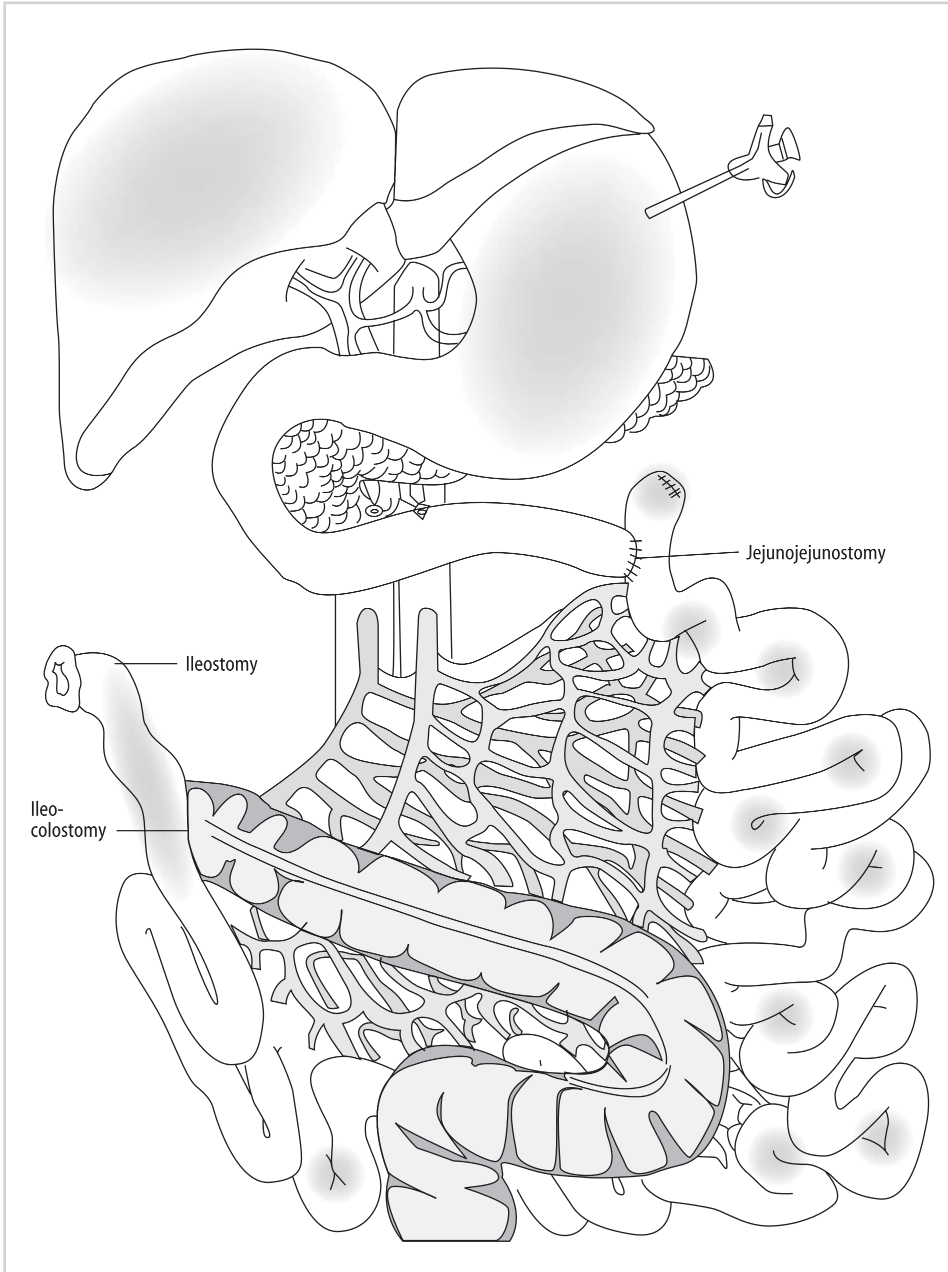

Figure 7.21

Combined Liver–Intestine Transplant

a) Donor Procedure

1. Donor management and operation begin as for isolated intestinal transplantation.[17] The gallbladder is incised and the biliary tract is flushed with saline. After broad Cattell and Kocher maneuvers, the tail of the pancreas and spleen are mobilized from the retroperitoneum, exposing the left lateral aspect of the aorta. Care is taken to avoid injury of the superior mesenteric vessels or the celiac axis (Figure 7.22).

The ligament of Treitz is widely mobilized. The proximal duodenum is then dissected at the level of the pylorus and divided with a stapling device. Care must be taken during this process to inspect the gastrohepatic ligament to avoid injury to an aberrant left hepatic artery if it is present.

2. After advancement of intraluminal contents distally, removal of the colon and systemic heparinization, the flush is performed with only aortic cannulation. Suprahepatic caval venting is performed.

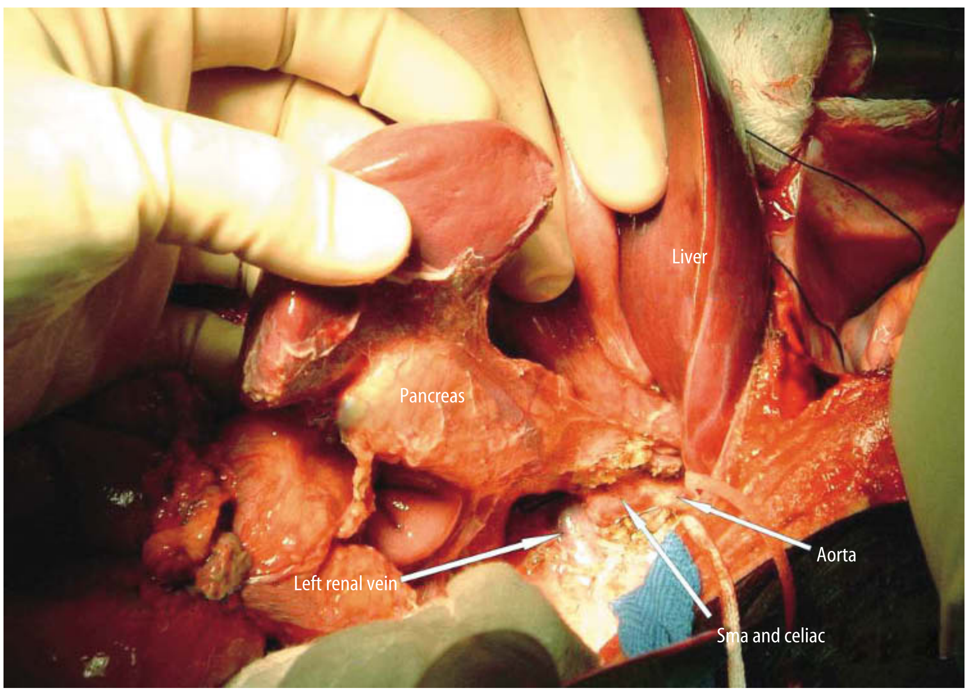

Figure 7.22

3. By retracting medially the spleen, pancreas and the small bowel in a cold lap pad, a Carrel patch or circumferential segment of aorta can then easily be taken, containing the origins of the celiac and superior mesenteric arteries. The plane is anterolateral on the left side of the aorta, and there is usually extensive mesenteric nervous plexus present in this tissue. Once this is divided, the aortic patch or segment can be clearly divided. Care must be taken not to injure the takeoff of renal arteries. If the kidneys are not being used (which is often the case with small pediatric donors), the entire aorta may be removed with the graft. We remove the entire aorta from iliac bifurcation to proximal descending aorta in the small pediatric donor; this requires the diaphragm to be split at the time of extraction. Then, the entire pancreas, spleen, small intestine and liver are removed *en-bloc* with intact inferior vena cava and duodenum (Figure 7.23).

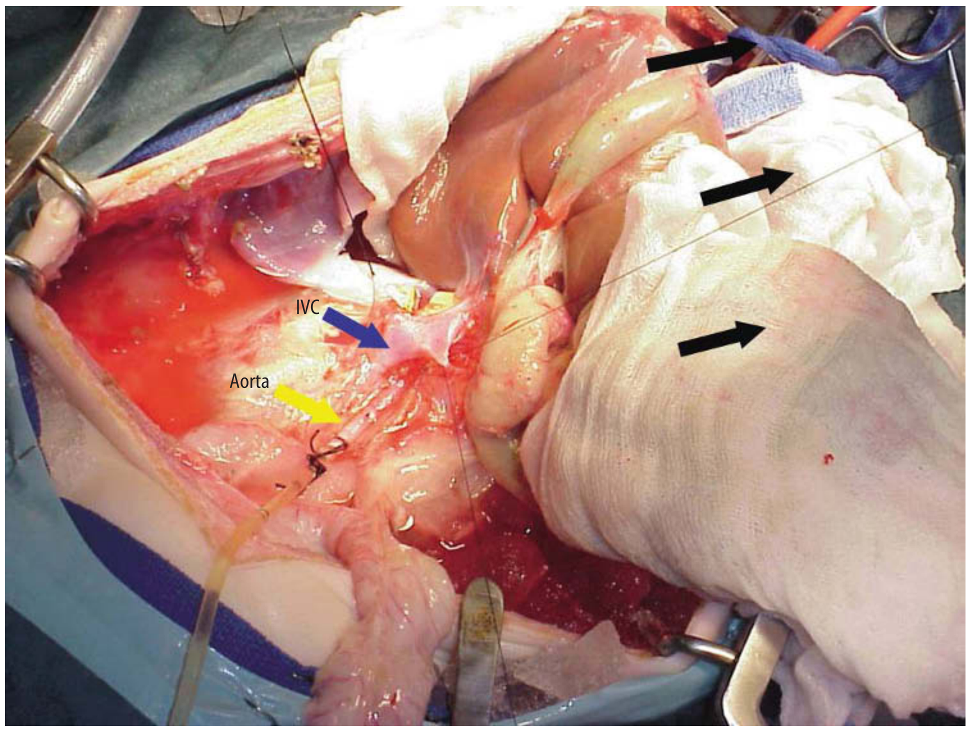

Figure 7.23

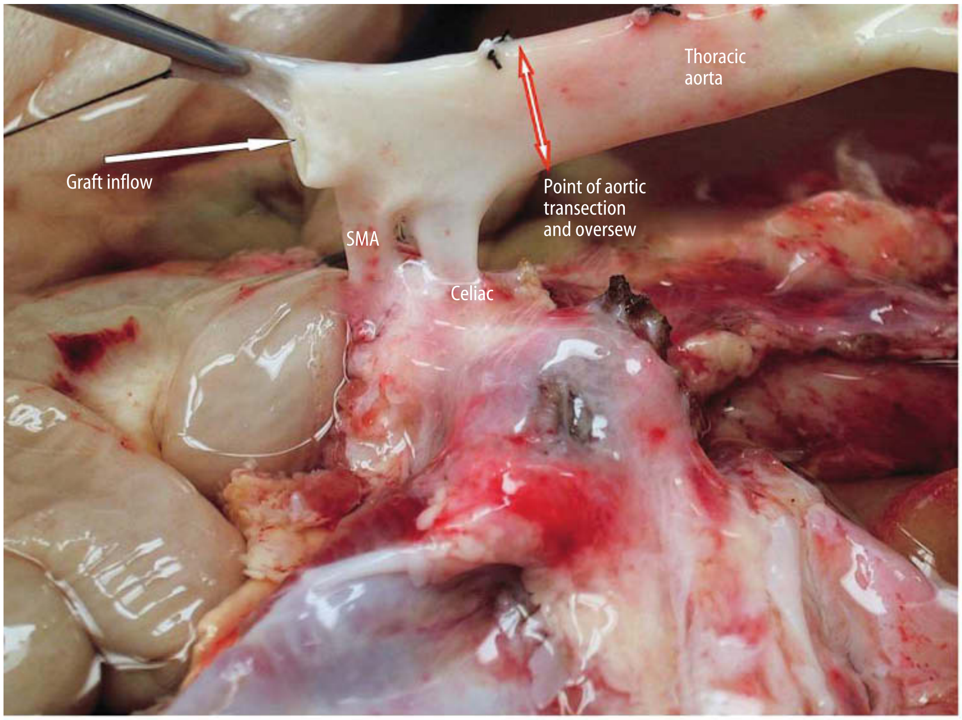

Figure 7.24

b) Back-Table Procedure

1. The back-table procedure requires cleaning of mesenteric and celiac plexus with ligation of vascular tissues surrounding these vessels. The celiac axis and superior mesenteric artery are exposed. Eventually the supraceliac aorta will be transected and oversewn (Figure 7.24). The thoracic aorta will then be used as a conduit from the native infrarenal aorta in a reversed interposition fashion.
2. The splenic vein and artery are dissected from the pancreas (Figure 7.25).

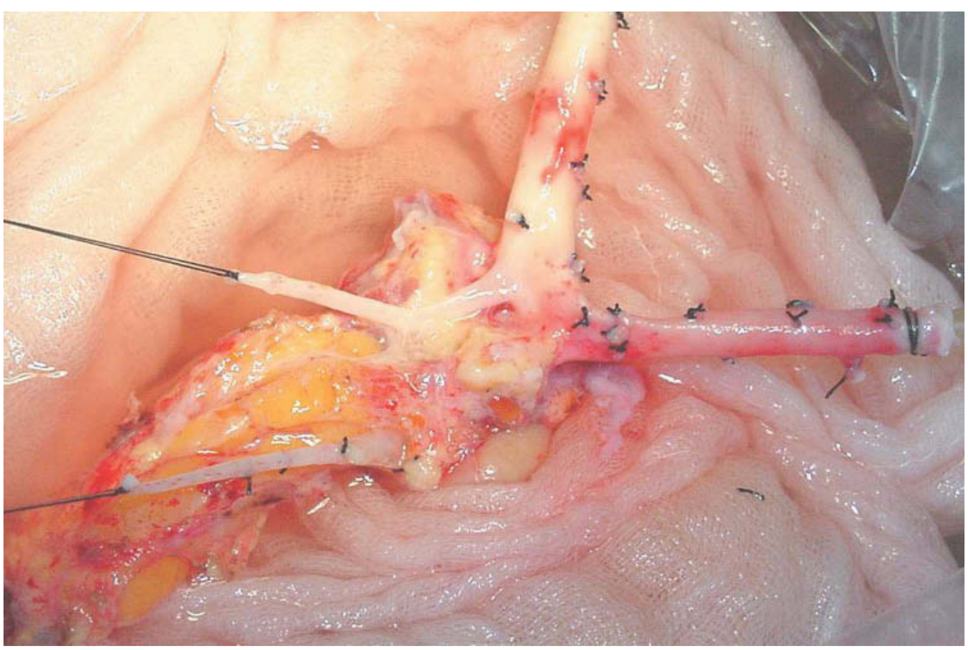

Figure 7.25

3. The pancreas is transected just to the left of the mesenteric vessels, and the splenic vein stump is used to flush preservation solution from the bowel before being ligated. It is important to oversew or staple the pancreatic remnant, reducing the pancreas gland and leading to a graft with intact duodenum with the pancreatic head. We prefer the use of a vascular stapling device for the pancreas (Figure 7.26). This technique is particularly suited to small pediatric donors in whom the pancreas is of sufficient size to warrant reduction.

4. The splenic artery must be ligated, but the gastroduodenal and inferior pancreaticoduodenal arteries are preserved, feeding the head of pancreas and duodenum to be transplanted with the allograft. If the pancreas is diminutive, no reduction is necessary. In infant donors, the small caliber of the aorta at the level of the SMA and celiac artery makes aortic inflow to the graft preferable. This can be performed using the supraceliac, infrarenal, or a transposed donor thoracic aortic segment as a conduit to the distal donor aorta (see figures in recipient procedure, below). The vena cava of the graft is then prepared as for isolated liver transplantation. The cut edge of the mesentery is evaluated closely and any small branches are sutured to avoid development of a hematoma in the mesentery. The vena cava of the liver should be prepared in the standard fashion.

The adult donor usually contains a larger pancreas gland, and this is more prone to leak if reduced. The entire pancreas may be transplanted with the liver–bowel allograft in order to facilitate use of the duodenal preservation technique. Alternatively, noncomposite transplantation of the orthotopic or piggyback liver and systemic or mesenteric isolated bowel implantation may be chosen, after removal of these two organs from the multiorgan en-bloc cluster that has been procured.

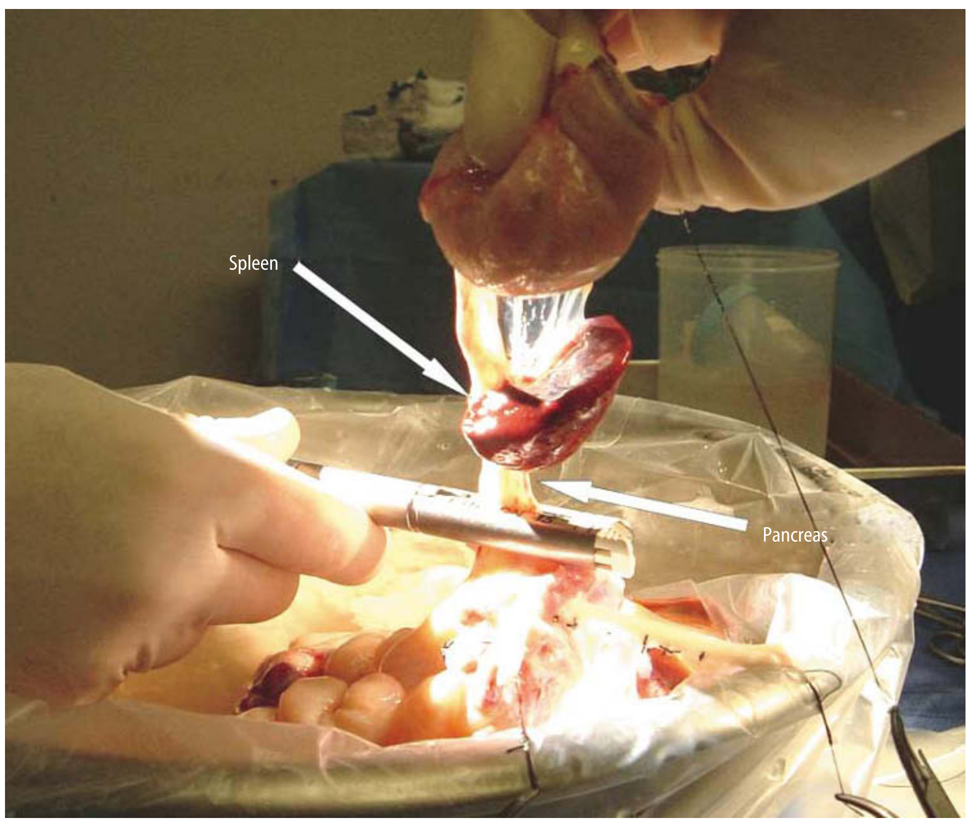

Figure 7.26

c) Recipient Procedure

1. This is most commonly accomplished using an en-bloc allograft with duodenal preservation. This technique allows for transplantation without disruption of the biliary system and hepatic arterial branches, and may be advantageous in small pediatric patients with tiny vascular and biliary structures that are otherwise easily injured.[11,12,18] The recipient is explored through a midline incision with bilateral subcostal extension, usually placed lower on the abdominal wall than for liver transplantation to provide improved lower abdominal exposure. Most patients will have prior incisions, and individualizing the opening may be required. Children have often undergone prior supraumbilical transverse incisions, which may be utilized.

2. Initial dissection of the liver hilum allows ligation of the hepatic artery and common bile duct. The portal vein is then skeletonized and the infrahepatic vena cava is isolated for construction of a portacaval shunt. Thereafter, the liver is dissected from the cava as for piggyback liver transplantation.

3. The infrarenal or supraceliac aorta is then exposed for anastomosis. Particularly among patients whose disease was inflammatory (i.e., necrotizing enterocolitis) adhesions may be dense and vascular, and care must be taken to avoid significant bleeding during this phase of the operation. Mobilization of the recipient duodenum is important to gain exposure of the infrarenal aorta. An aortic extension graft (either donor thoracic aorta or a bifurcation iliac artery graft) can now be placed on the recipient infrarenal aorta to facilitate inflow to the graft. Alternatively, some prefer to use supraceliac aorta, with direct anastomosis of the donor supraceliac aorta. This is easiest to expose during the anhepatic phase. We have found that smooth bloodless preparation of the site of graft arterial inflow prior to liver explantation is critical to a short warm ischemic implantation procedure and overall technical success.

4. The hepatic veins can now be clamped and the native liver is removed, maintaining long cuffs for anastomosis. Because the native foregut is preserved, a portocaval shunt must be performed to provide venous outflow for these organs after the composite liver–bowel graft is transplanted.[13,19] An end-to-side portocaval shunt is constructed most efficiently during the anhepatic phase (Figure 7.27).

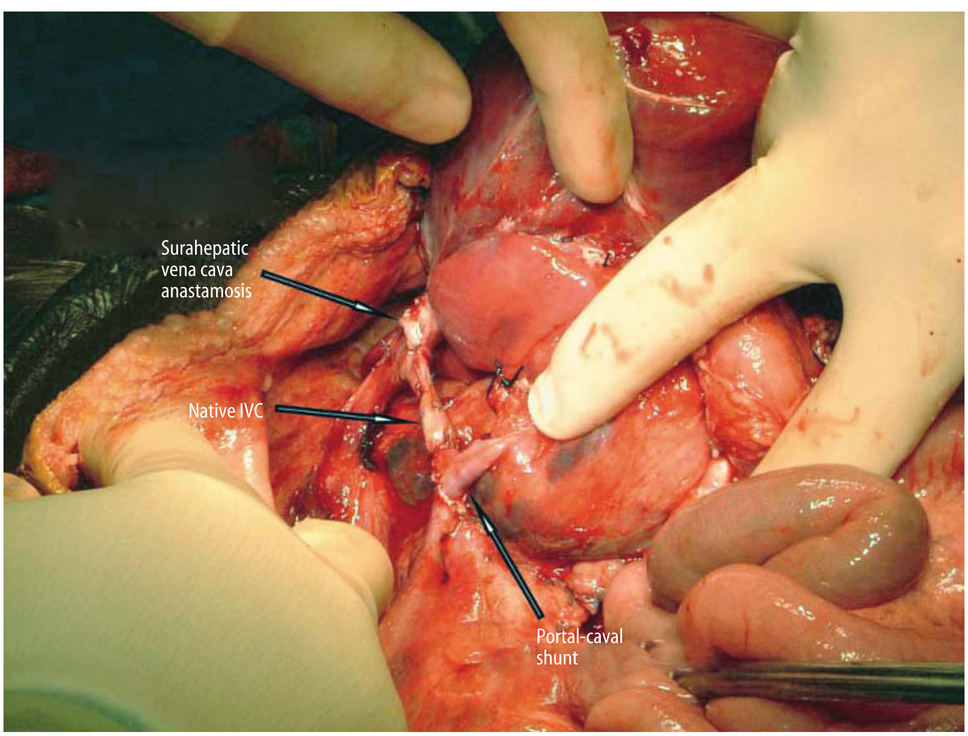

Figure 7.27

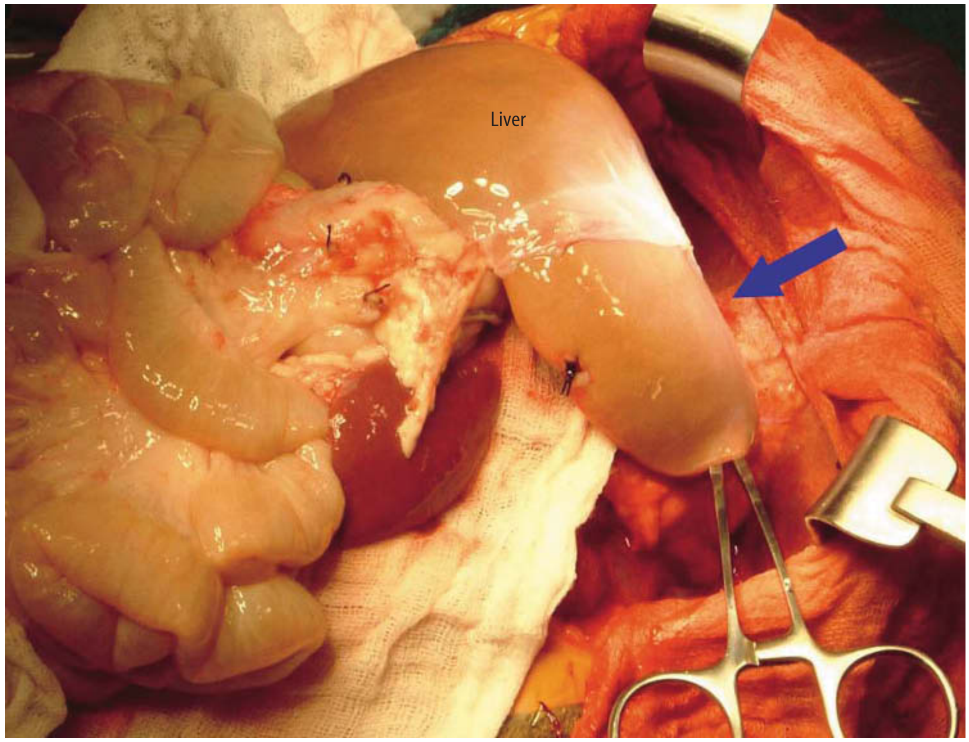

Figure 7.28

5. With relief of the portal hypertension, the adhesions from multiple prior operations can be lysed, taking care to avoid enterotomy, which otherwise may be disastrous. The graft is brought to the table and the suprahepatic caval anastomosis (blue arrow) is performed as in piggyback liver transplantation (Figures 7.28 and 7.29).

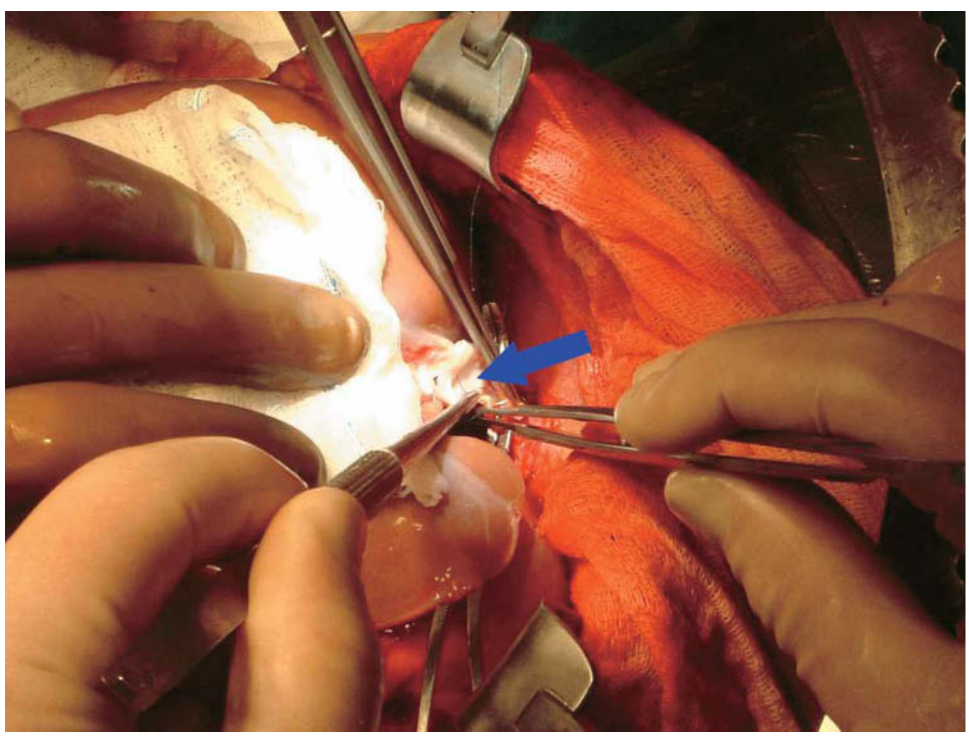

Figure 7.29

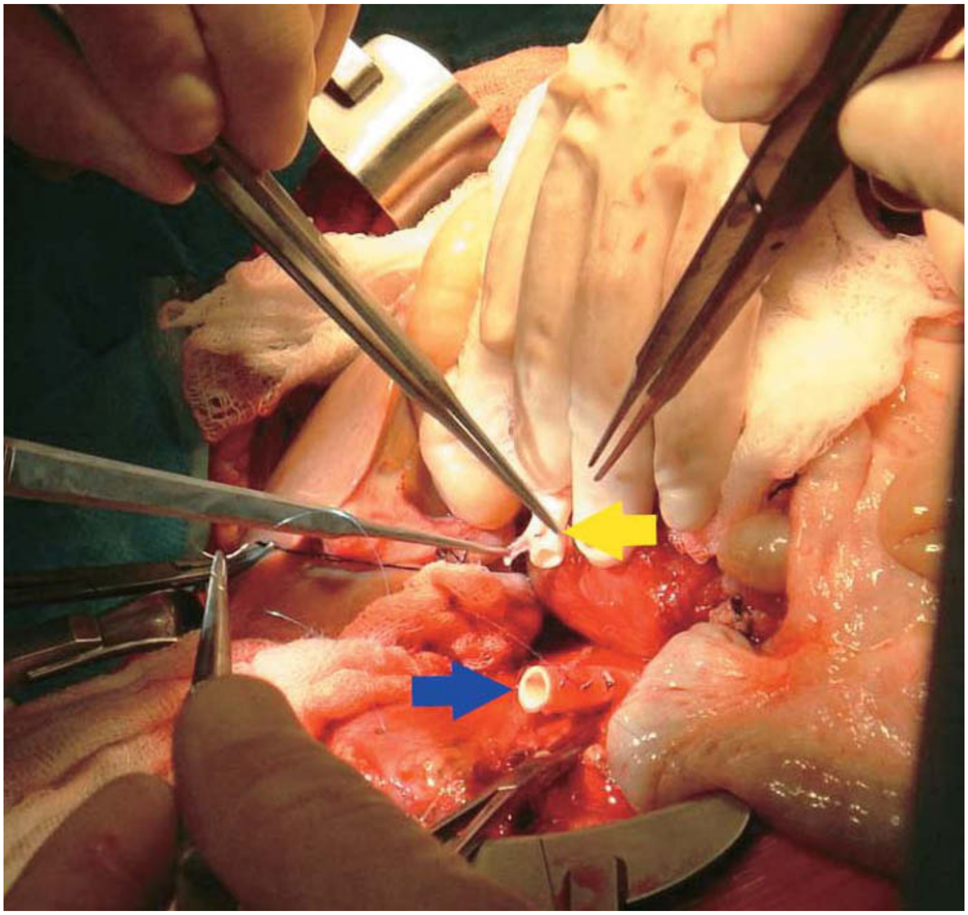

Figure 7.30

6. The Carrel patch or SMA/celiac complex (yellow arrow) can now be anastomosed either directly to the aorta or more commonly to an interposition conduit of donor thoracic aorta (blue arrow) (Figures 7.30 and 7.31) or bifurcating iliac artery.

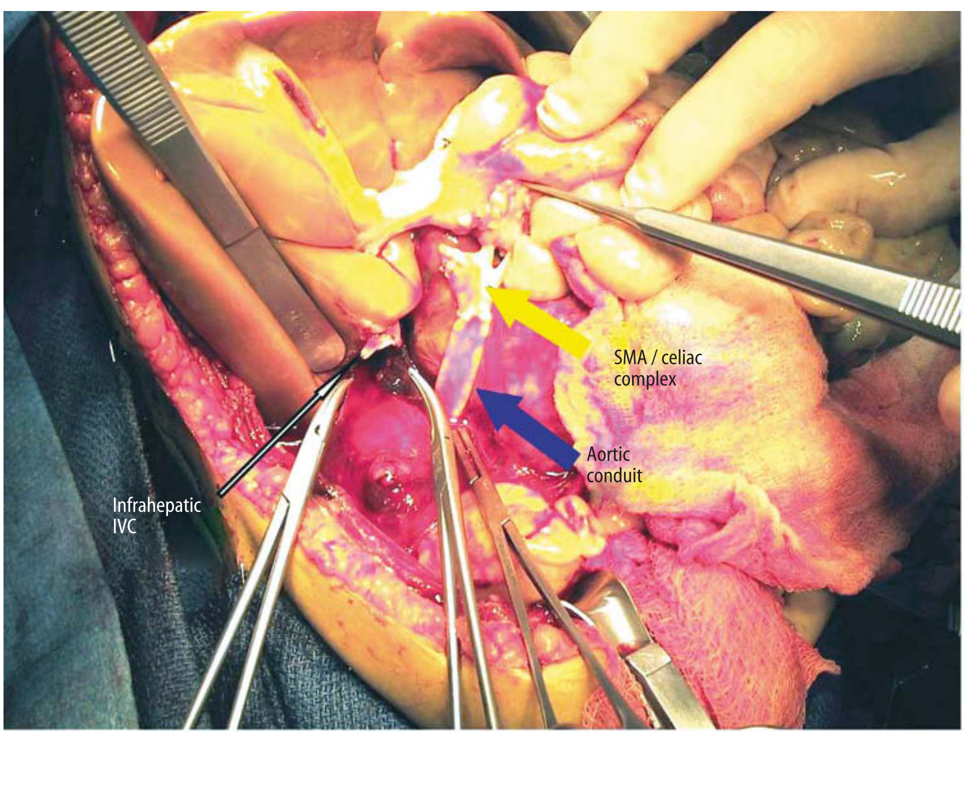

Figure 7.31

7. The stump of the splenic vein may be used to vent preservation solution, and if this is planned, the surgeon should isolate and prepare the splenic vein orifice during the back-table procedure (prior to transection of the pancreas).[20] Cholecystectomy is performed in the usual fashion.

8. Enteral continuity is reestablished with jejunojejunostomy after removal of most of the proximal recipient small bowel, anastomosis being performed distal to the ligament of Treitz of the allograft. Distal anastomosis is accomplished as with isolated intestinal allografting (Figure 7.32).

9. In some cases, it may be preferable to place separate liver and intestinal allografts, rather than employing the en-bloc allograft technique.[21] Severe portal hypertension and dense adhesions may make the aortic exposure required for combined transplantation difficult. Placement of the liver prior to aortic exposure can facilitate transplantation when faced with this difficulty. The piggyback liver transplant is performed, and the isolated intestinal transplant procedure with systemic drainage is then performed.

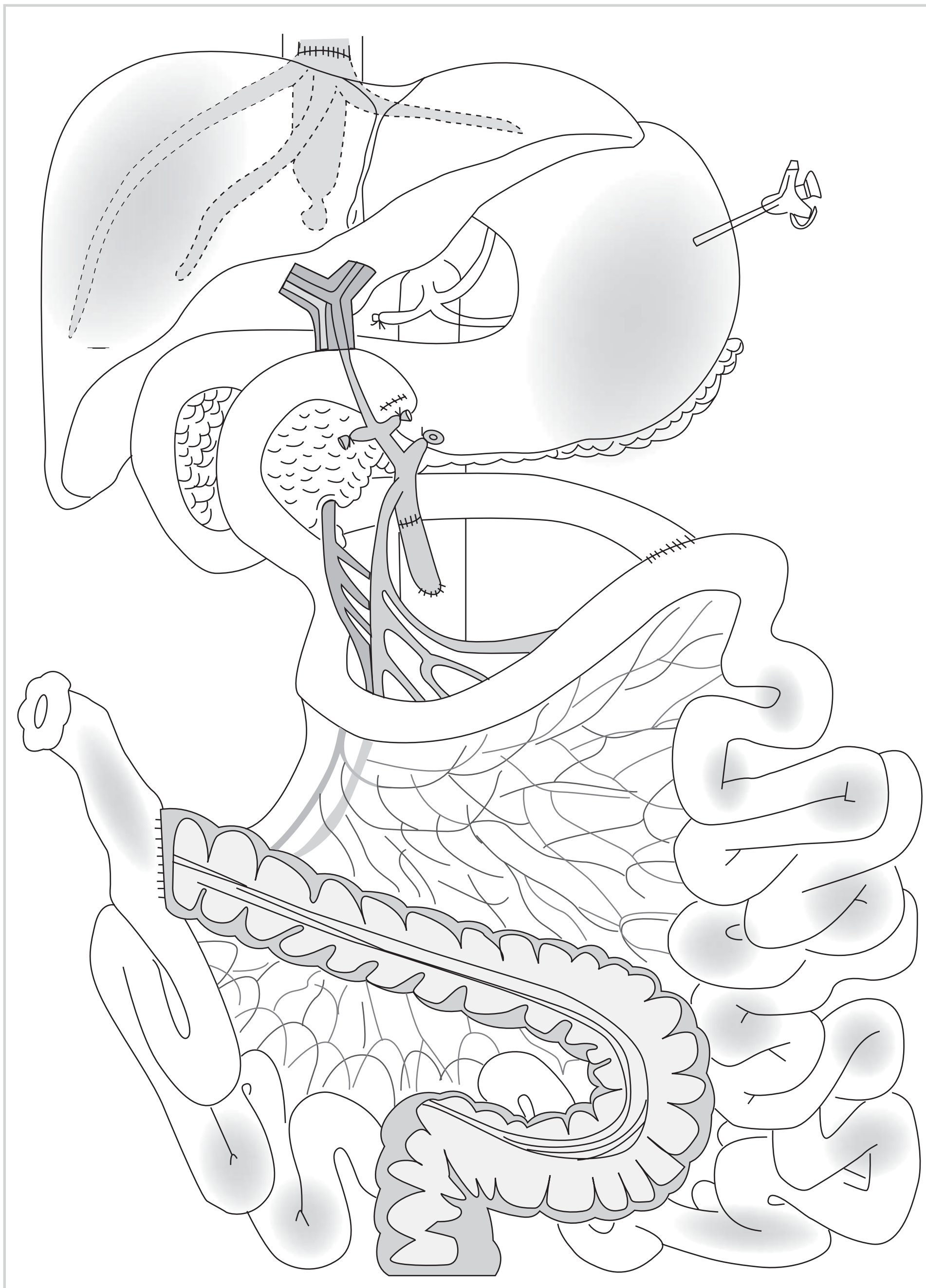

Figure 7.32

Multivisceral Transplant

a) Donor Procedure

1. Donor procurement is fundamentally the same as in the liver–intestine procurement except that variable amounts of the stomach or colon are preserved with the graft. Recipients with disorders of motility and gastric dysfunction may benefit from inclusion of the stomach in the allograft. Recipients with severe chronic pancreatitis usually require inclusion of the entire pancreas. Tumors of the mesentery sometimes require removal of the entire gastroduodenal complex, and patients suffering familial adenomatous polyposis sometimes have gastric, duodenal, or periampullary polyps requiring removal. Some children may rarely require concomitant renal transplantation. In this case, one or both pediatric kidneys can be kept in continuity with the allograft, with either the distal or the thoracic allograft aorta used for inflow. The renal arteries and veins are not disrupted from their connections to the aorta and vena cava. The fundamental technical alterations are preservation of the left gastric artery, careful preservation of the gastroepiploic arcade when removing the greater omentum (Figure 7.33), and enteric division of the gastroesophageal junction, rather than the pylorus or jejunum.

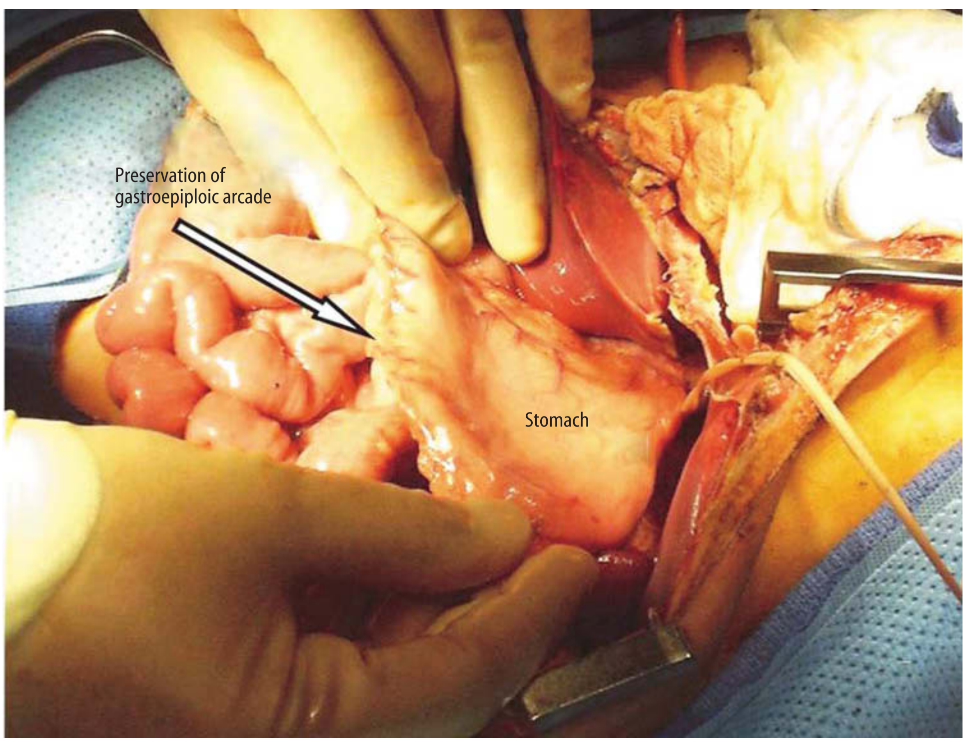

Figure 7.33

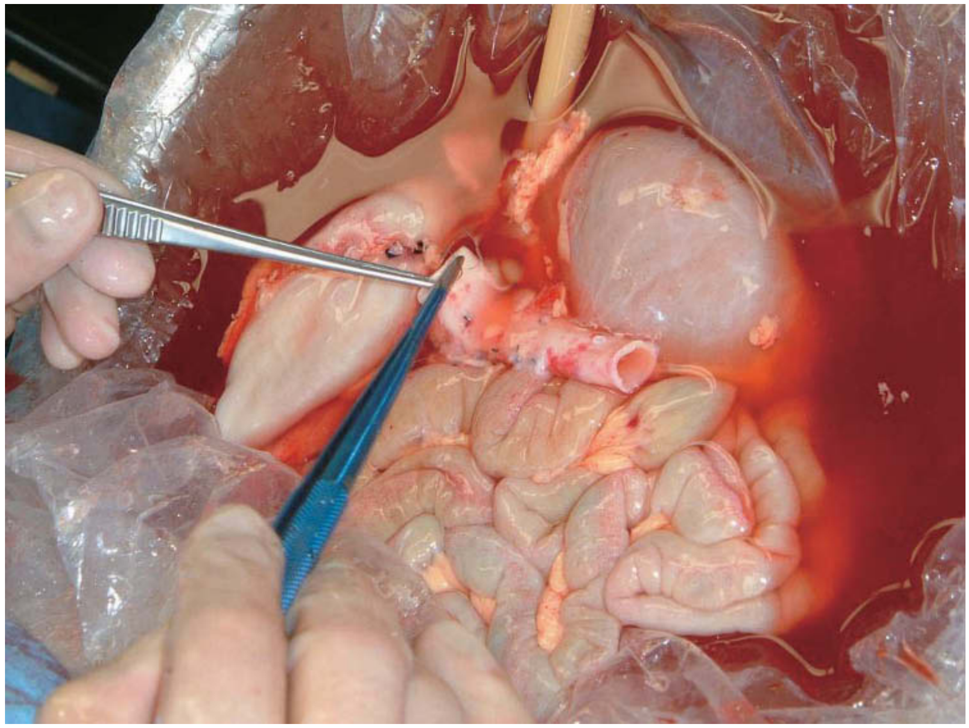

Figure 7.34

2. The abdominal viscera are then removed en bloc with the vena cava and the same Carrel patch or intact aorta (Figure 7.34), as would be the case with liver–intestine procurement.

b) Recipient Procedure

1. This transplant procedure is different from the previously described ones in that the entire splanchnic circulation with accompanying organs is removed; no portocaval shunt or bypass is therefore necessary. The pancreas and spleen, the root of the intestinal mesentery, the stomach, and the liver are removed together, preserving vena cava continuity. Thus, the recipient operation is similar to the multivisceral donor operation itself. The procedure begins with mobilization of the liver from the retrohepatic vena cava to allow piggyback placement of the allograft. No portal dissection is required.

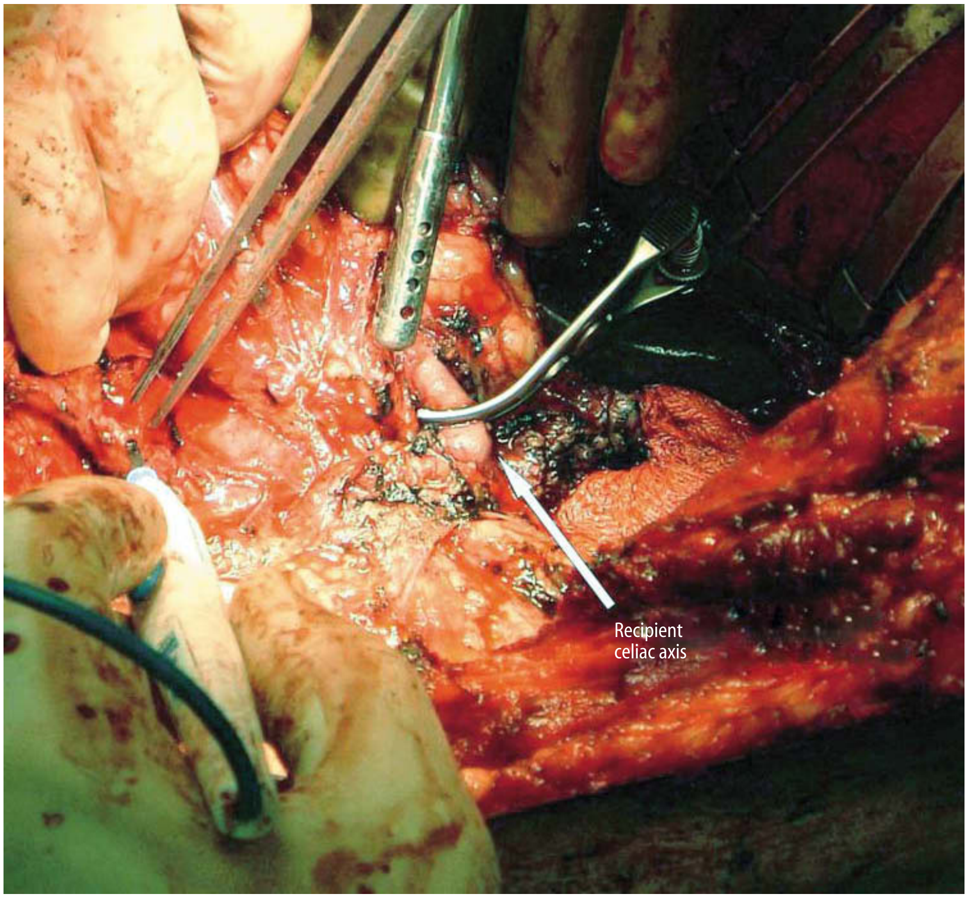

Figure 7.35

2. Next, the proximal stomach is isolated, allowing for division with a stapling device, preserving the gastroesophageal junction in the recipient, with descending blood supply from the esophagus. This exposes the supraceliac aorta, sometimes allowing the celiac to be identified. However, this is most easily found proceeding from the left with a medial visceral rotation, leading to isolation of the base of the celiac and superior mesenteric arteries from the anterolateral left approach (Figure 7.35). Cattell and Kocher maneuvers (if the colon is intact) expose the right side of the superior mesenteric artery, and mobilization of the entire base of the intestinal mesentery.

3. The left colon is divided, taking care to preserve the left colic artery and inferior mesenteric arteries, as no collateral flow from the superior mesenteric artery will exist after exenteration. Vascular clamps can then be placed on the base of the celiac and superior mesenteric arteries and they may be transected. This step leaves the patient functionally anhepatic, so preparation to remove the organs prior to this step is critical. The hepatic veins are clamped and divided. The stomach, pancreas, spleen, small bowel, right colon, and liver are removed together, preserving the inferior vena cava for piggyback allograft implantation.

4. The hepatic venous piggyback anastomosis is usually performed first, aligning the graft in proper position.

5. Inflow must be brought to both the celiac and superior mesenteric arteries. Two inflow vascular anastomoses may be used, using the native celiac and superior mesenteric arteries end-to-end with the same donor structures (our preferred method), using an iliac bifurcating graft to these vessels from either the supraceliac or infrarenal aorta after ligation of the native vessels, or through a single anastomosis of infrarenal aorta of the donor allogaft end to side to the infrarenal aorta of the recipient (Figure 7.36).

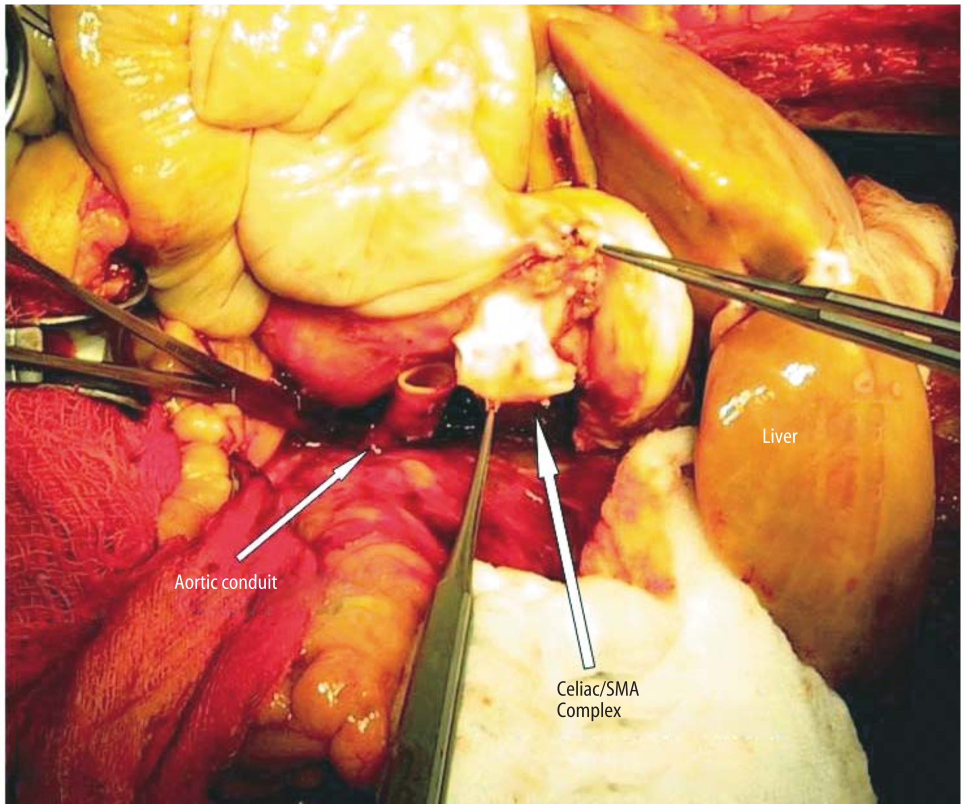

Figure 7.36

6. Preservation of a cuff of native stomach allows for a two-layer gastrogastric anastomosis, rather than an esophagogastric anastomosis. We have encountered no anastomotic leakage with this technique.[22] Pyloroplasty is required to provide gastric emptying of the denervated stomach. Distal enteral continuity is reestablished with ileostomy construction and colon anastomosis as described above (Figures 7.37 and 7.38).

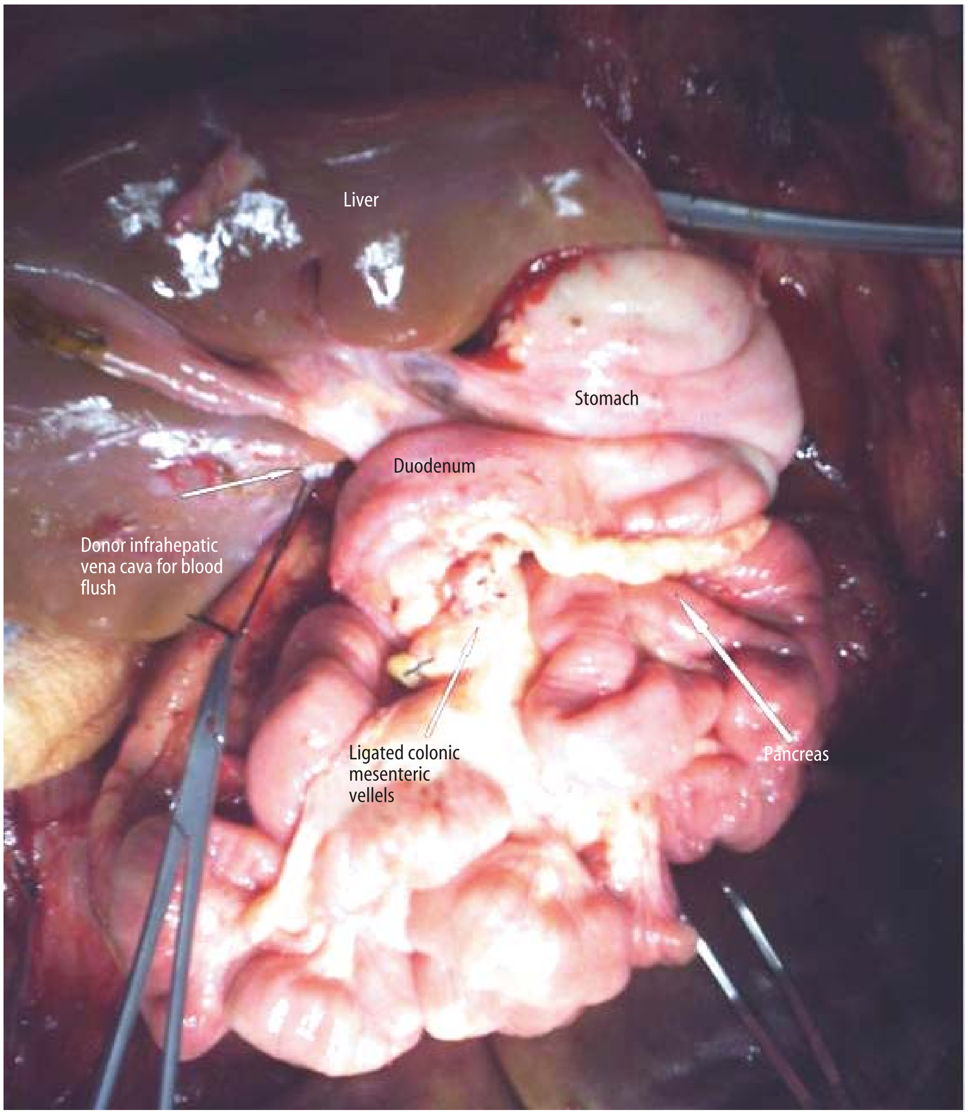

Figure 7.37

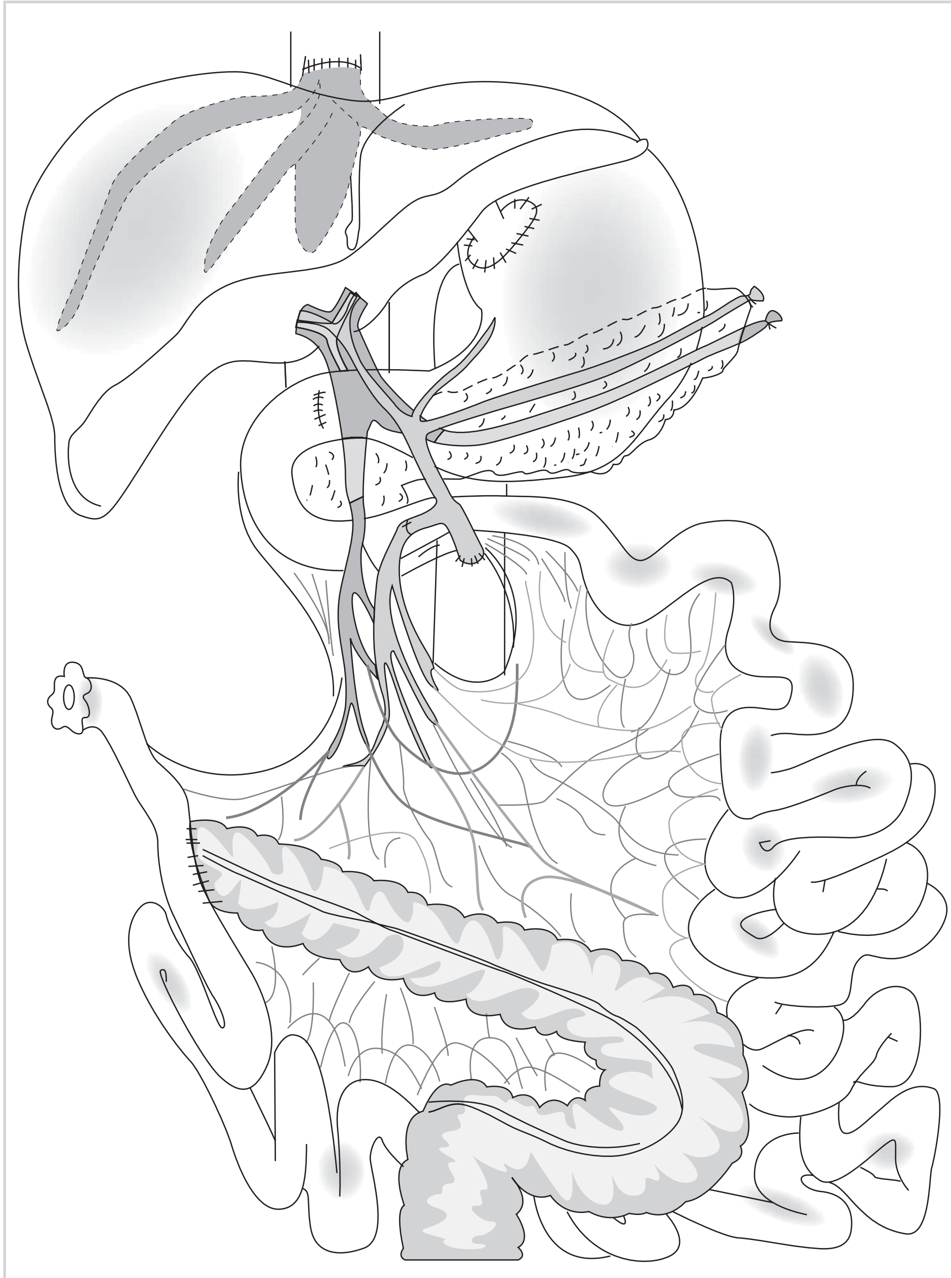

Figure 7.38

Figure 7.39

7. Transplantation of the stomach may result in either gastric stasis or mild dumping, and some form of gastric decompression tube is mandatory, usually with a combined gastrostomy-jejunostomy tube to allow early feeding into the graft jejunum. Drains are placed in case of the development of chylous ascites that may emanate from the graft after a fat-containing diet is resumed (Figure 7.39).

Living-Donor Small-Bowel Transplant

Very few small-bowel transplants have been done to date utilizing living donors. Less than 50 cases have been reported to the International Intestinal Transplant Registry. Primarily this is because the results with deceased donors are satisfactory, and the issues with organ shortage are not as great as with liver or kidney transplant. Nonetheless, the mortality list on the waiting list is high, especially in pediatric patients. Use of living donors has the potential advantages of lowering waiting time, reducing preservation injury, and allowing for better human leukocyte antigen (HLA) matching.[25–28]

Various segments of bowel have been reported to have been used for such transplants, but the most experience is with a long segment of the donor terminal ileum as the graft for the recipient. In this scenario, approximately 150 to 200 cm of distal ileum is used. The graft inflow is based on the distal part of the superior mesenteric artery (SMA); graft outflow is based on the corresponding part of the superior mesenteric vein (SMV).

As with all living-donor transplants, donor selection is a critical part of the process. Potential donors should be ABO blood group compatible and carefully evaluated for possible cardiopulmonary risk factors. The medical evaluation is not too dissimilar to the evaluation for a potential kidney donor. Specific to the potential small-bowel donor is radiologic imaging to evaluate the anatomy of the superior mesenteric vessels. This can be done with conventional selective mesenteric angiogram. However, this is an invasive test with some potential risk. The same information can be obtained with a good-quality computed tomography (CT) angiogram with three-dimensional reconstructions.

a) Surgical Procedure

1. A midline incision is made and the abdominal cavity is explored. The first important step is to measure the length of bowel and mark the portion to be removed (Figure 7.40). The last 20 to 30 cm of terminal ileum, including the ileocecal valve, should be preserved in the donor. Therefore, starting at the ileocecal valve, 20 cm is measured proximally and the bowel is marked here, which represents the distal margin of resection. The bowel is then marked 150 to 200 cm proximal to this, which represents the proximal resection margin. One should also ensure that at least 60% of the total small-bowel length will be left in the recipient.

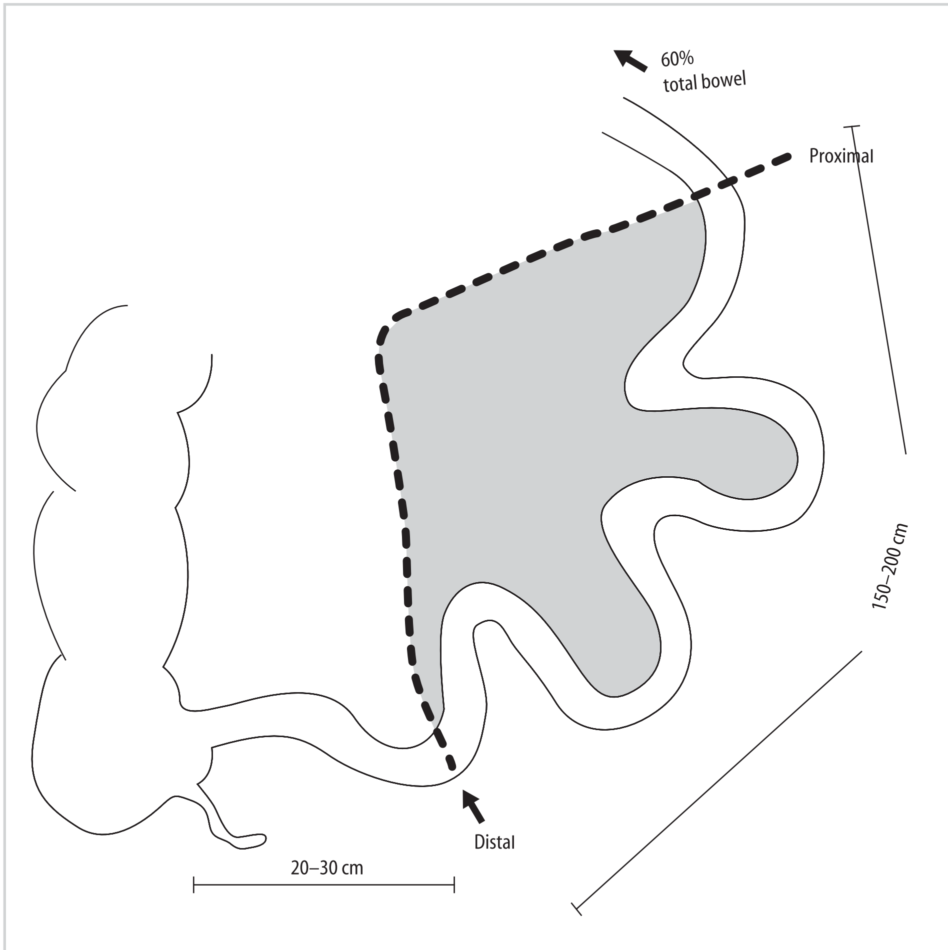

Figure 7.40

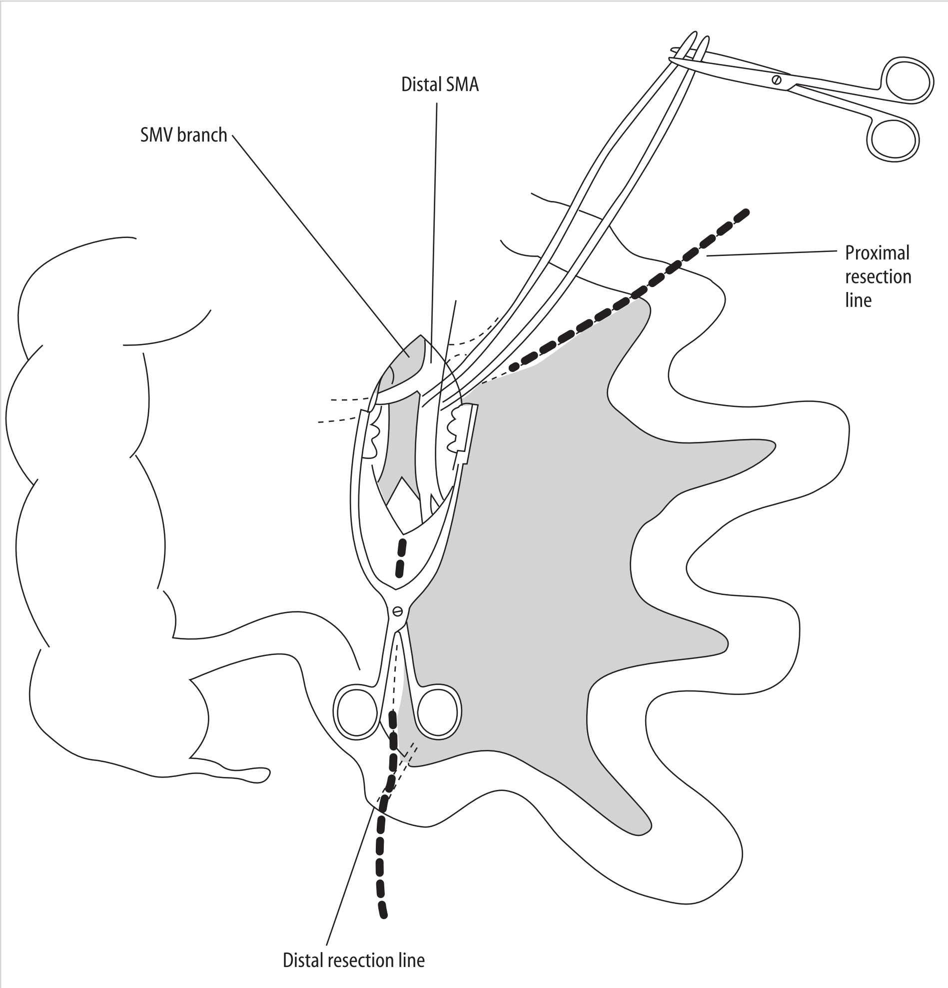

Figure 7.41

2. Using transillumination and palpation, the distal branch of the SMA is identified, and dissected free for 2 to 3 cm. Care should be taken to ensure that this is distal to the major branches of the SMA that supply the jejunum, proximal ileum, and right colon. The corresponding portion of the superior mesenteric vein is identified next to the artery and dissected free for a similar length (Figure 7.41).

3. Next, the mesentery of the bowel to be removed is scored and divided. This is done in a V-shaped fashion, with the apex corresponding to the mobilized portion of the SMA and SMV, and the two ends corresponding to the proximal and distal resection margins (Figure 7.42).

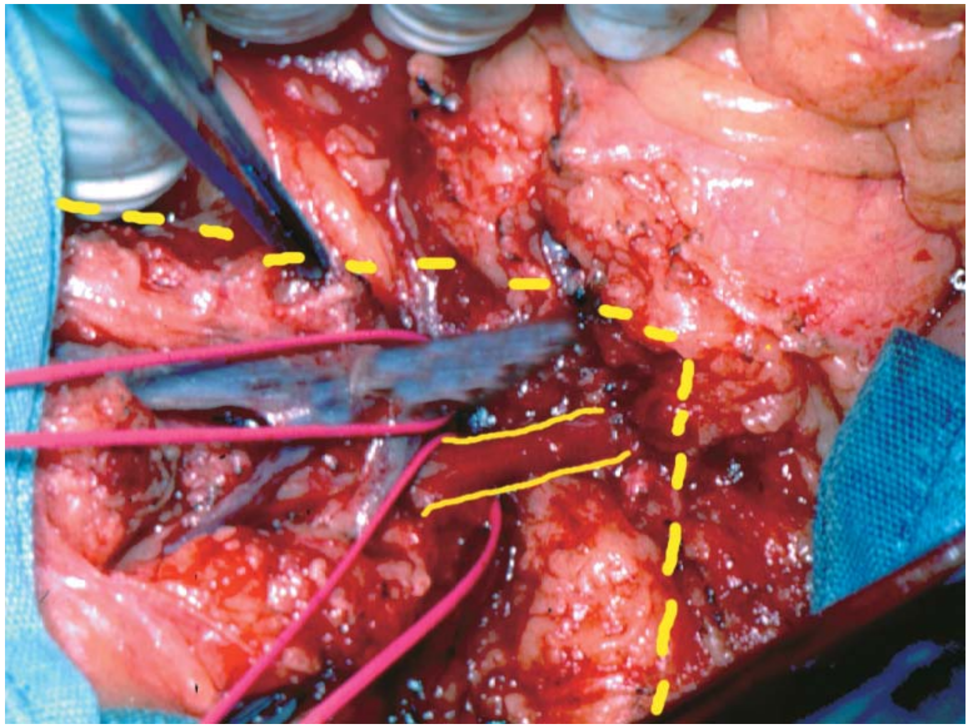

Figure 7.42

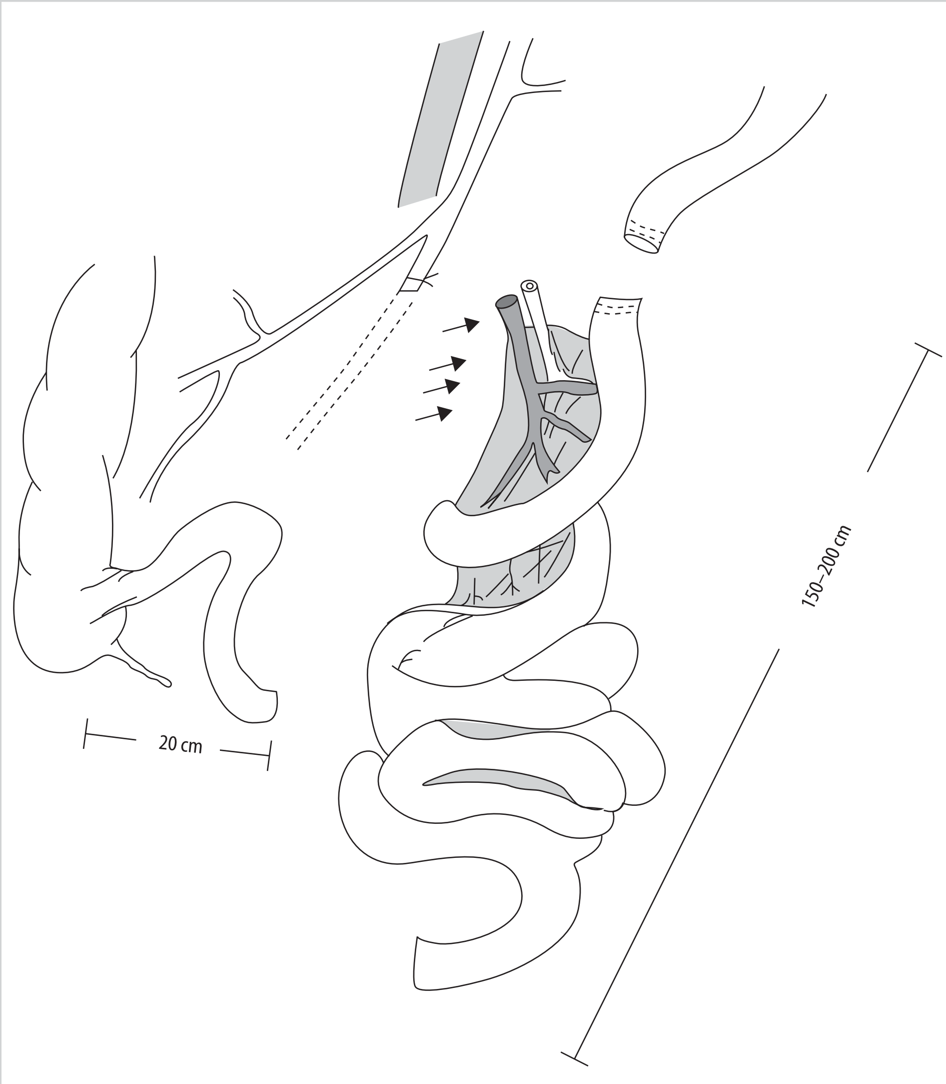

Figure 7.43

4. The bowel is divided proximally and distally. The vessels are divided after application of vascular clamps. The graft is removed and flushed (Figure 7.43).

5. The two divided ends of the bowel are reapproximated either with a stapler or in a hand-sewn fashion to create an end-to-end anastomosis (Figure 7.44). The defect in the mesentery is closed, followed by closure of the incision.

6. The recipient operation first involves isolation of the vessels to be used for inflow and outflow of the graft. The infrarenal aorta and inferior vena cava are most commonly used. End-to-side anastomoses are performed for the vein and artery of the graft (Figure

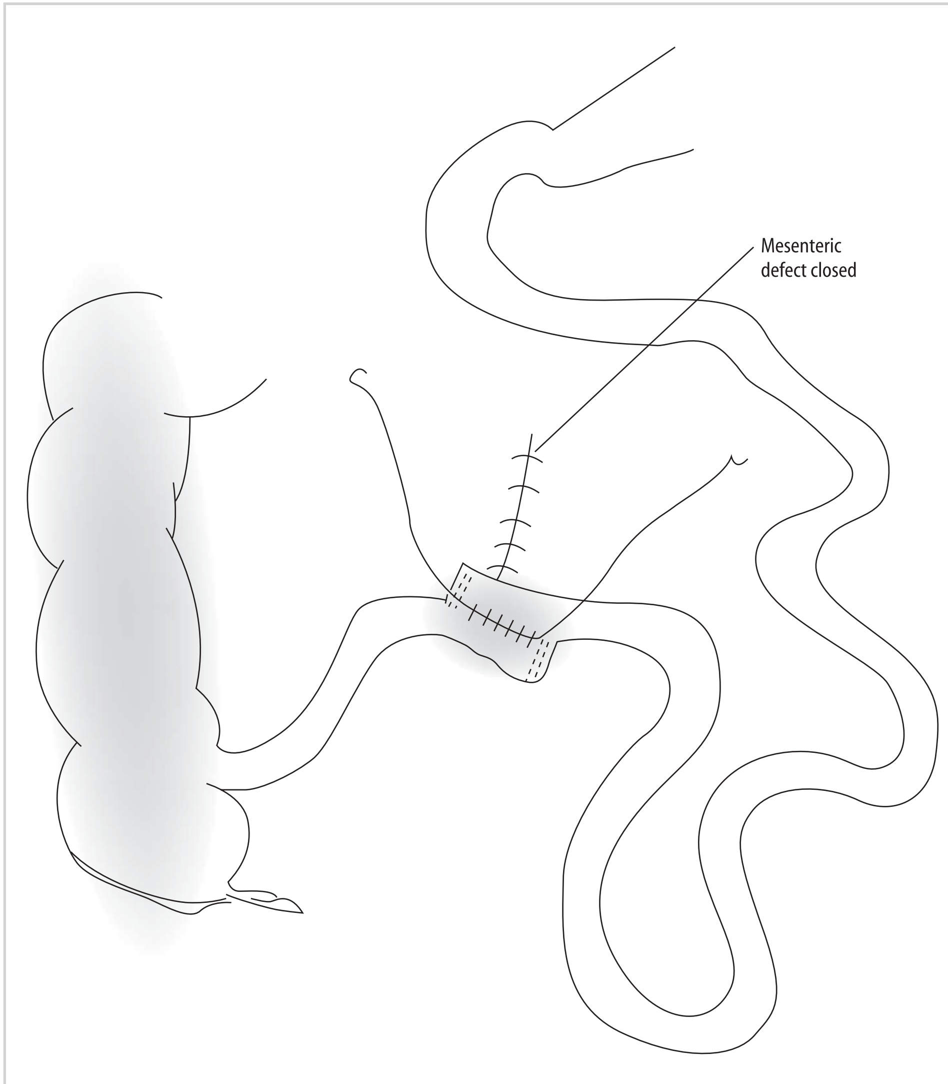

Figure 7.44

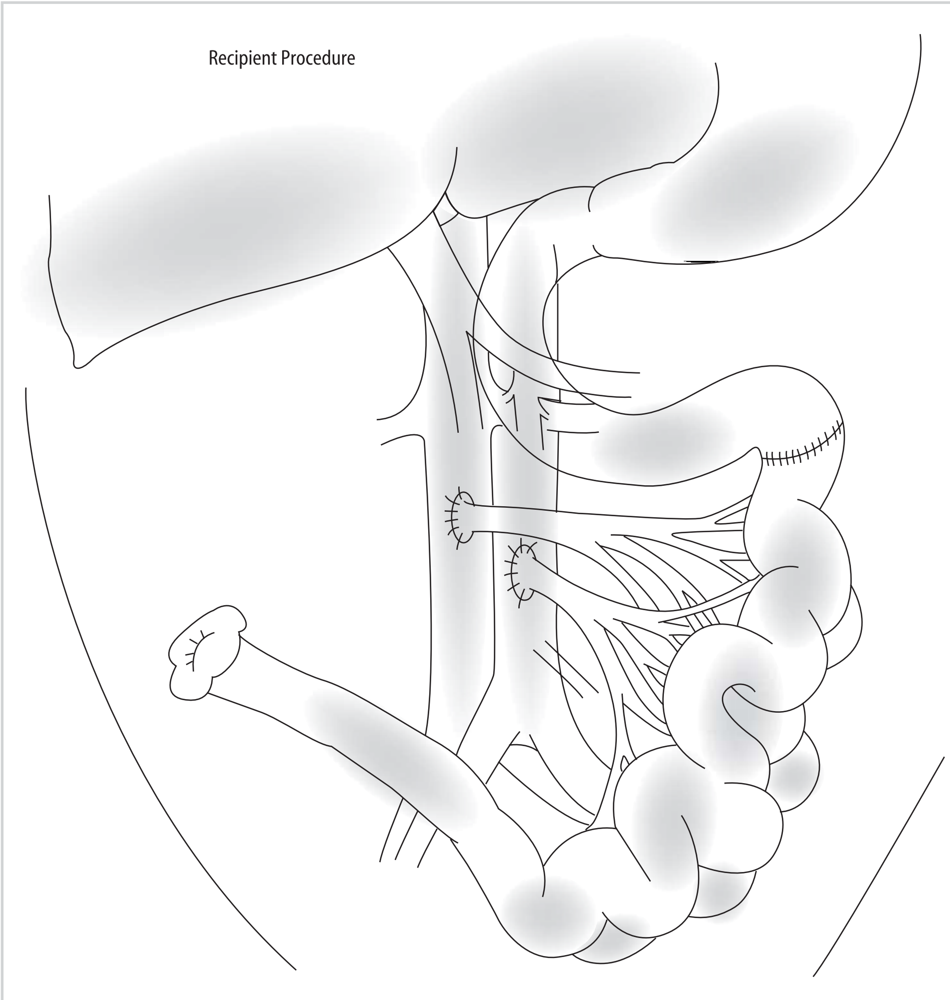

Figure 7.45

7.45). Once the bowel is reperfused, intestinal continuity is restored by anastomosing the proximal end to the recipient remnant bowel. The distal end is usually brought out as an ileostomy.

Perioperative Management

Patients require intensive care immediately after transplant. They generally remain intubated in the early postoperative period, although isolated intestinal transplant patients may be extubated early. In the first 24 hours, the transplanted intestine usually produces minimal stool, but third-space losses can be significant, requiring aggressive hydration. If kidneys are transplanted with the graft, the urine output should be replaced on an hourly basis accordingly. Finally, pulmonary artery catheter pressures or transthoracic echocardiography may be employed to help guide fluid management at the discretion of the critical care team. The intestinal vasculature is sensitive to vasoconstrictive agents, particularly α-adrenergic agents, and they should be avoided. Sepsis syndrome that requires intervention usually indicates the need for reoperation due to vascular compromise or perforation. Because the graft is exteriorized with an ileostomy, blood flow to the graft may be assessed with Doppler flow at the bedside, rather than ultrasound duplex, which is made difficult by overlying bowel gas. A bedside nurse may employ a fetal Doppler hourly to assure good waveform as would be done for a vascularized free flap.

Electrolyte imbalances should be corrected aggressively with intravenous delivery. The transplanted bowel after the first few days may exhibit calcium and magnesium malabsorption with high ileostomy outputs, although this usually does not develop until after the institution of enteral nutrition. Water, sodium, and bicarbonate may be lost in large quantities with high ileostomy outputs. This may lead to a characteristic metabolic acidosis, requiring sodium bicarbonate added to the intravenous or enteral formula for correction. Hypomagnesemia potentiates tacrolimus-related neurotoxicity and should be avoided.

Intravenous broad-spectrum antibiotics should be continued early after transplantation or until the first biopsy confirms mucosal integrity of the transplanted bowel. Some patients will have lost the right of domain of the abdominal cavity and will return to the intensive care unit closed with a prosthetic mesh. Although we carefully match donor and recipient sizes, at times abdominal lavage and staged closure is necessary. A dedicated line for parenteral nutrition should be maintained during the intensive care unit stay, as the average time to the achievement of complete enteral nutrition after intestinal transplantation is approximately 1 month.[1,11] We generally institute feeding 5 days after transplantation if no reoperation is planned, and early graft function is adequate, judged by initiation of stomal output.

Conclusion

Intestinal transplantation is a very technically demanding field, requiring intimate knowledge of advanced techniques in both liver transplantation and gastrointestinal surgery. Some degree of individualization of procedures is required, based on each recipient's gastrointestinal anatomy, function, and vascular complications of parenteral nutrition. Appropriate technical and logistical planning will minimize unnecessary complications and keep ischemic times short, and have helped attain the current acceptable outcomes.

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