

CHAPTER

1

# Organ Procurement

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*Algorithm and Explanation:  
Approach to the Potential Organ Donor*

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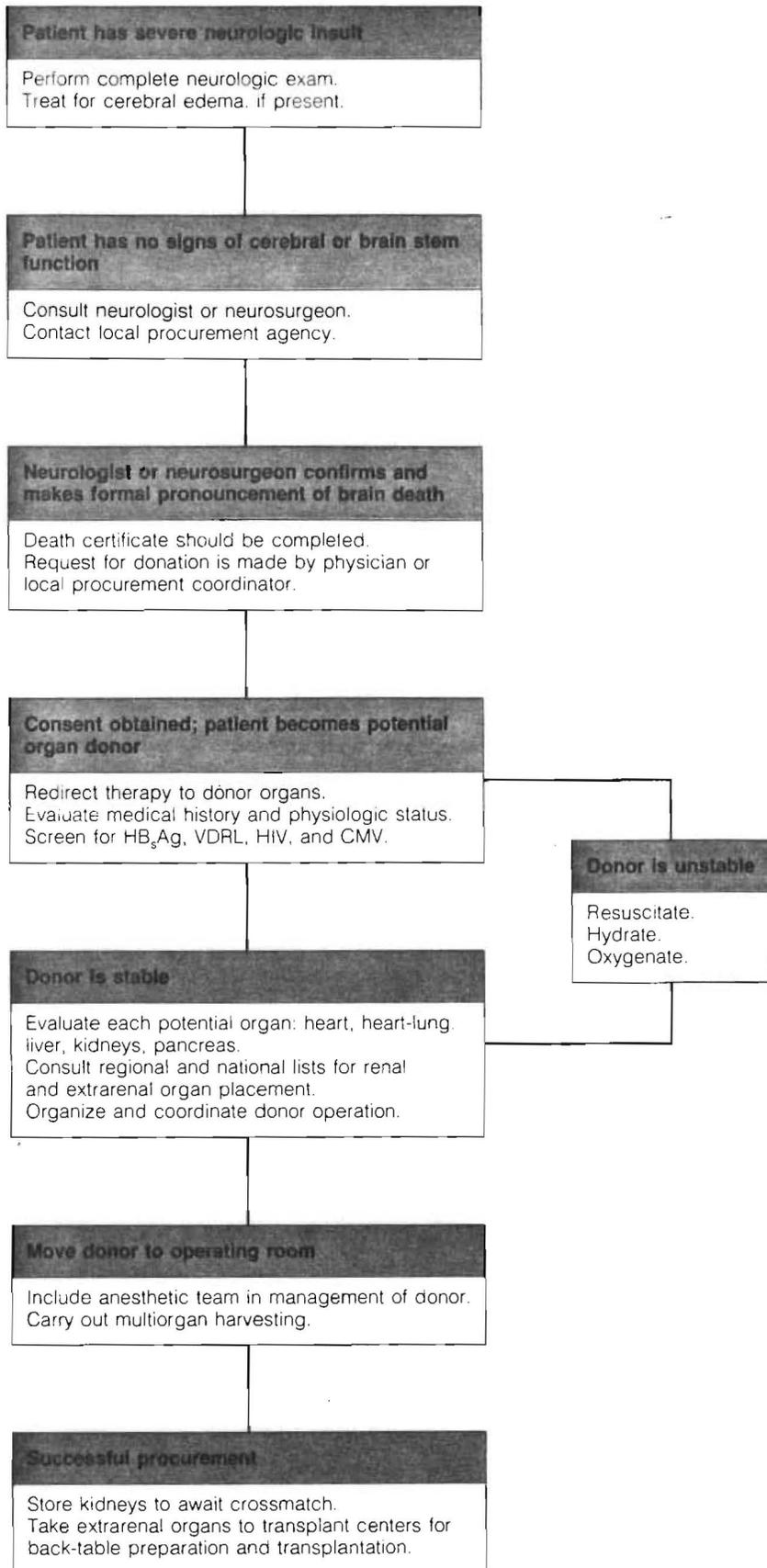
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# Approach to the Potential Organ Donor

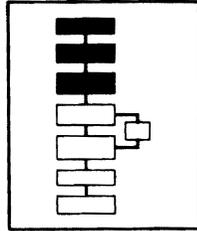


# 1 ORGAN PROCUREMENT

## *Approach to the Potential Organ Donor*

### Preliminary Steps

When a patient presents with severe neurologic insult, initial efforts should be directed at saving the injured patient by minimizing cerebral swelling and possible brain herniation [see IV Trauma, 1 Trauma to the Central Nervous System]. Often, this is best accomplished by strict fluid restriction and the administration of diuretics and mannitol. However, one of the key advances in clinical organ transplantation has been improved identification and early referral of potential organ donors. Any patient who has suffered severe brain damage should be considered for organ donation. Causes of such damage include external trauma, motor vehicle accidents, falls, assault, spontaneous intracerebral hemorrhage, drowning, hanging, primary brain tumors, drug overdose, and sudden infant death syndrome.



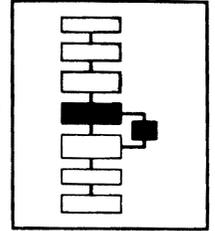
A neurologist or neurosurgeon, or both, should be consulted early in the evaluation of a patient with a severe neurologic insult. Such consultation will be important in an eventual diagnosis of brain death, which can be made on clinical criteria alone<sup>1</sup> but is often confirmed with electroencephalography<sup>2</sup> or occasionally a cerebral flow scan,<sup>3</sup> or both. Clinical criteria include deep coma, lack of spontaneous movement, a positive apnea test, and no response to deep pain. In addition, cranial nerve reflexes, such as the oculocephalic (doll's eyes) and oculovestibular (caloric), should be absent. Brain-dead patients have fixed, dilated pupils and do not have protective corneal reflexes. Spinal reflexes may still be present because they do not involve the higher centers of the brain or brainstem.<sup>4,5</sup> If the patient has stable cardiovascular function, the clinical criteria of brain death usually are documented twice within an interval of six to 12 hours before a final declaration of death is made.

As soon as the possibility of donation is established, the local organ procurement agency should be contacted. (The telephone numbers of these agencies are available in most intensive care units.) The procurement coordinator then evaluates the patient's potential for organ donation, assists in the administrative details necessary for declaration of death, and acts as intermediary between the hospital and the donor's family.

When brain death is confirmed, the attending physician or neurologist should make a formal pronouncement in the patient's chart and complete the death certificate. The physician or the procurement coordinator may then formally request consent for donation from the family, making sure that family members completely understand the diagnosis of brain death and the organ procurement process.

### Donor Evaluation and Management

After the declaration of brain death, efforts must be redirected to protect the organs to be transplanted rather than the now dead brain. Usually such therapy entails aggressive rehydration. In addition, the procurement coordinator must clearly establish the adequacy of each organ to be used, according to well-recognized sets of standard criteria (see below). A detailed medical history must be obtained that includes the cause of the brain damage as well as the donor's age, height, weight, and blood type. Assessment of acute physiologic status can be made by measuring blood pressure, central venous pressure (CVP), urine output, and arterial blood gases. Serologic analysis for syphilis (VDRL), hepatitis B surface antigen (HbAg), cytomegalovirus, and human immunodeficiency virus must be done<sup>6</sup>; otherwise, recipients may be infected with these deadly organisms.



The criteria for renal donation are the most flexible. A kidney donor can be between the ages of six months and 70 years. Levels of serum creatinine and blood urea nitrogen (BUN) should be normal, although elevations may be caused by dehydration or other adverse but reversible acute states. If dehydration is responsible, BUN and creatinine levels should fall after adequate fluid replacement.

Kidneys can be preserved after nephrectomy for up to 72 hours, but the chances that a kidney will function immediately in the recipient diminish greatly with storage for more than 24 hours. Thus, there may be time for tissue typing and matching before sending kidneys to recipients in distant cities. Time constraints for preservation are much more stringent in the procurement of extrarenal solid organs. Livers, hearts, and lungs should be transplanted within six hours of removal from the donor; the same is probably true for the pancreas. There is no consensus on the upper age limits for extrarenal donation, but many groups exclude donors who are more than 40 years of age.

If the liver is under consideration for donation, normal or near normal SGOT, SGPT, and bilirubin levels must be documented. A history of hepatitis or alcoholism is a warning sign but not necessarily a contraindication to liver transplantation.

Heart and heart-lung donors must have no history of cardiac disease and should have a normal chest x-ray, electrocardiogram, and physical examination. The  $P_{aO_2}$  of heart-lung donors should be 350 mm Hg during ventilation with a fraction of inspired oxygen ( $F_{I O_2}$ ) of 1. Sputum cultures and Gram's stains should be negative. In trauma cases, tests of cardiac isoenzymes should also be negative.

ABO blood group and organ size are important factors in placing extrarenal organs. Ideally, a liver donor should be slightly smaller than the proposed recipient, but large variations on this generalization may occur, according to the size of the recipient liver that is to be removed. In heart transplantation, the donor organ usually should be slightly larger than that of the recipient because cardiomegaly is a common finding in the recipient. The height, weight, and chest circumference of the heart-lung recipient must closely match that of the donor. The donor team is responsible for accumulating the information on which wise recipient selection can be based.

During the evaluation, the donor must be maintained in a stable physiologic state.<sup>7</sup> Because the basic physiologic situation rarely, if ever, improves in brain-dead patients, the interval between pronouncement of death and procurement surgery should be kept as short as possible. If a donor is unstable, aggressive therapy must be directed at maintaining adequate circulation, ventilation, and diuresis. If the donor is dehydrated from prior efforts to prevent cerebral edema, rapid repletion will be required with crystalloid solutions or colloid solutions, or both.

One relatively simple guide to fluid therapy is to maintain the central venous pressure between 10 and 12 cm H<sub>2</sub>O, if a normal systemic blood pressure can be achieved. However, brain death is sometimes associated with severe neurogenic shock and peripheral vasodilatation, and in such cases, the peripheral vascular resistance will not support a normal systemic blood pressure, no matter how well the heart is loaded. In these patients, vasopressors, such as dopamine, should be added to restore normal blood pressure. Norepinephrine bitartrate (Levophed) and metaraminol bitartrate (Aramine) should be avoided because they produce severe visceral and renal vasoconstriction and may injure the organs to be transplanted.

Respiratory care of the potential donor is the same as for any ventilator-dependent patient in an intensive care setting. Chest x-rays should be obtained at least once a day. Frequent endotracheal suctioning must be done, good pulmonary toilet must be maintained at all times, and arterial blood gases must be monitored frequently. Oxygen saturation should be maintained at no less than 95 percent by adjusting the F<sub>I</sub>O<sub>2</sub> settings on the ventilator [see *II Care in the ICU, 4 Use of the Mechanical Ventilator*]. Levels of positive end-expiratory pressure (PEEP) greater than 5 cm H<sub>2</sub>O are not recommended because the higher levels increase intrathoracic and right atrial pressures, which in turn may cause hepatic parenchymal congestion and preclude the use of the liver.

A stable brain-dead donor should produce urine at a rate of at least 1 ml/kg/hr. The most common cause of oliguria is hypovolemia. If the CVP is low, further fluid resuscitation is in order. In some instances, however, oliguria may be the result of acute heart failure that is secondary to excessive fluid resuscitation, and osmotic and loop diuretics, such as mannitol and furosemide, will be needed.

When trauma to the brain is severe, pituitary function often fails. The resulting absence of antidiuretic hormone causes diabetes insipidus, and a large volume diuresis ensues, which can lead to severe volume depletion and donor instability. Most cases of diabetes insipidus can be handled simply by replacing the urine output intravenously with half-normal saline. Serum electrolytes must be monitored frequently during such treatment because hyponatremia can easily be produced. If fluid replacement cannot keep up with the diuresis, intravenous vasopressin

may be given, but only with great caution, because the resulting vasoconstriction can cause severe end-organ ischemia.

### Coordination of Donor and Recipient Activities

After the donor has been identified, studied, and stabilized, the procurement team contacts regional transplant programs about their needs for renal and extrarenal organs and inquires about needs in other parts of the country. A national computer registry of potential recipients of renal and extrarenal organs is maintained by the United Network for Organ Sharing (UNOS). (The 24-hour UNOS number is 1-800-446-2726.)

Potential recipients of extrarenal organs are categorized according to ABO blood group, weight, acceptable weight range of the donor, distance the recipient team is willing to travel for procurement, length of time the patient has been on the transplant list, and medical urgency status. Urgency is rated from 3 to 0, with 3 indicating the most stable patients and 0 those in extremely urgent need. The 0 now replaces the previously used status 9 category.

For extrarenal organs, first priority is commonly given to recipients within the region of procurement; second priority is given to the recipient center that has the greatest need and that can best accommodate the many logistic constraints involved. Arrangements for placement of extrarenal organs are always made prior to harvesting.

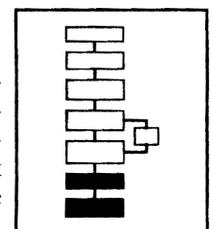
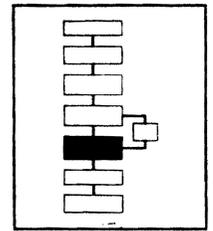
In contrast, kidneys not used regionally are almost always placed at some significant time following their removal. Placement of leftover kidneys has been based heavily on the results of tissue typing, which usually is performed after donor nephrectomy. Opinions vary widely, however, about how much weight tissue matching should be given over organ viability in deciding to which geographic region the kidneys should be sent. The actual viability of kidneys as a function of preservation time needs to be reexamined with care because the issue has not been given the priority it deserves.

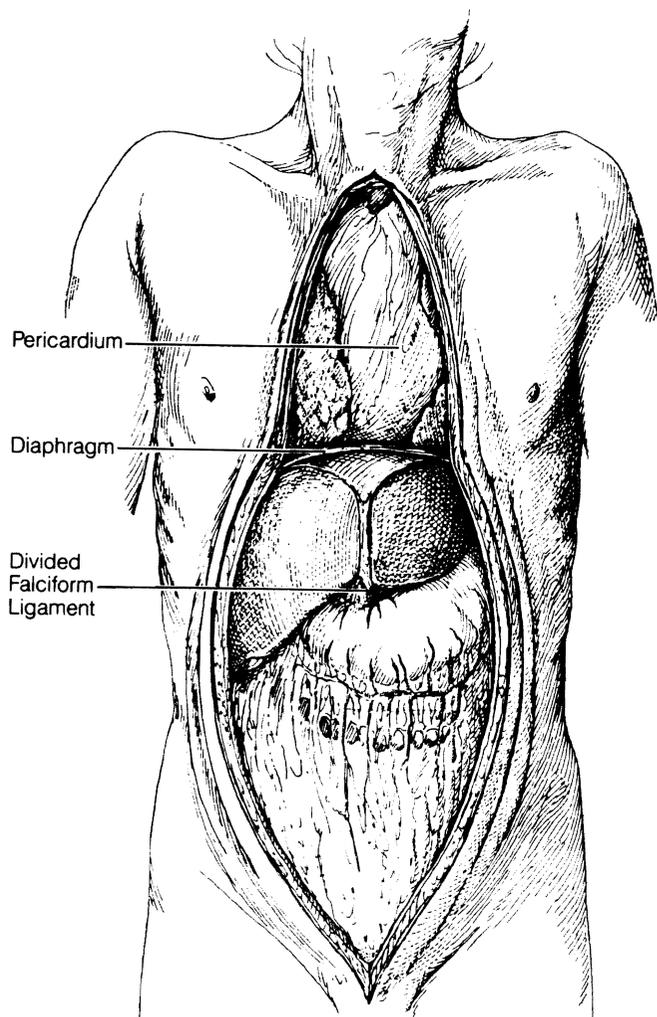
Once recipients for extrarenal organs have been identified, the local procurement team must coordinate the arrival of the participating recovery teams, schedule the operating room for donor surgery, and maintain the stability of the donor. With cooperation from all participants, including promptness, the different procurement teams will arrive as the donor is transported to the operating room. Before the actual operation, the renal and extrarenal procurement teams should coordinate their techniques and preferences to avoid unseemly conflicts during a multiple-organ harvest.

### The Donor Operation

When the donor is brought to the operating room, the anesthetic team begins to participate in donor management. If spinal reflexes persist in the donor a muscle relaxant such as pancuronium bromide should be administered.

The operation for multiple-organ procurement must proceed in such a way that the kidneys, liver, heart, heart and lung, or various combinations of these or other organs can be removed



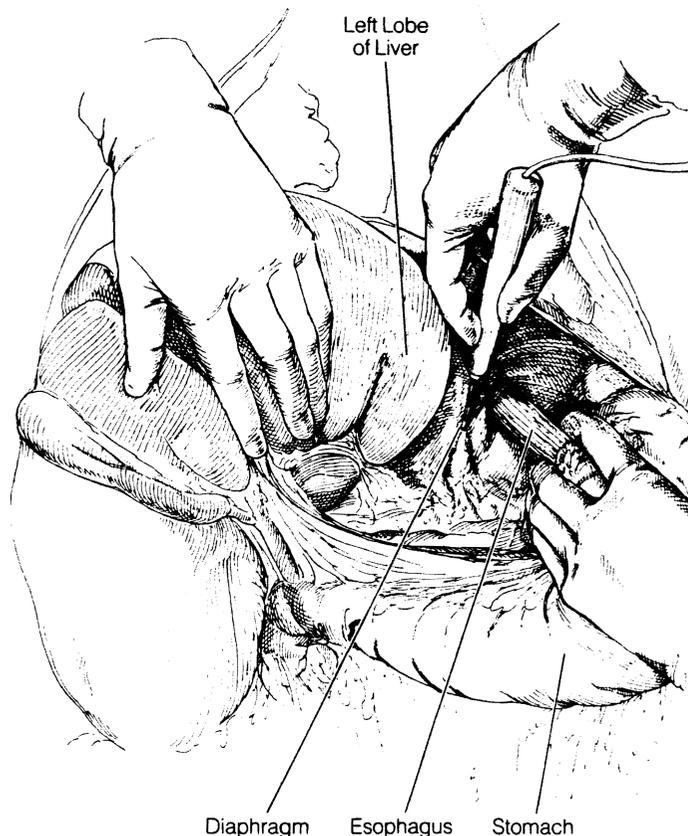


**Figure 1** The incision used for multiple organ procurement is made from the suprasternal notch to the pubis, as illustrated here.

without jeopardizing any of them. The basic principle of the procedure is to carry out preliminary dissection of the great vessels of the abdomen and chest. The aorta is cross-clamped at preplanned levels so that the organs to be removed can be core cooled in situ with cold intra-aortic and intraportal infusions (see below).<sup>8</sup> Thus, warm ischemia is avoided in the donor organs. This technique has been adopted as an international standard and in its most refined version<sup>9</sup> can be done in less than an hour, from beginning to end.

To start, a complete midline incision is made from the suprasternal notch to the pubis [see Figure 1]. If a heart team is on hand for cardiectomy, the pericardium is opened and the heart is inspected. Very minimal dissection is required to prepare the heart for removal. The superior vena cava and the aorta are encircled with tapes to allow for eventual occlusion of the inflow and outflow tracts. The heart team can complete its preliminary work in 10 to 15 minutes.

The abdominal team, which consists of hepatic and renal surgeons, can also finish their preliminary work in 10 to 15 minutes. The left triangular ligament of the liver is incised, the esophagus



**Figure 2** The crura are divided between the esophagus and the vena cava to facilitate exposure and encirclement of aorta at the diaphragm.

is held to the left with a finger, and a longitudinal incision is made in the diaphragmatic crura, between the retrohepatic inferior vena cava and the esophagus [see Figure 2]. The aorta is encircled with a tape at this level.

The abdominal team now turns its attention to the more distal aorta, ligating and dividing the inferior mesenteric artery and encircling the aorta at this level [see Figure 3]. The inferior mesenteric vein (IMV) is isolated and ligated. A cannula is inserted into the IMV and advanced superiorly for approximately 5 cm in adults and for lesser distances in children so that the tip is in or just entering the portal vein. Finally, after systemic heparinization, the distal aorta is ligated and the aortic perfusion cannula is inserted [see Figure 3].

Formerly, procurement procedures for kidneys and liver included extensive further dissection of the hepatic hilar structures: skeletonizing of the hepatic arterial supply, the common duct, and the portal vein before terminating the circulation.<sup>9</sup> In addition, the renal surgeons commonly freed up the ureters from the bladder to the ureteropelvic junction and performed variable dissections of the renal veins and arteries.<sup>9</sup> Inexperienced teams



**Figure 3** The inferior mesenteric artery is ligated and divided. Catheters are inserted into the inferior mesenteric vein and into the distal aorta.

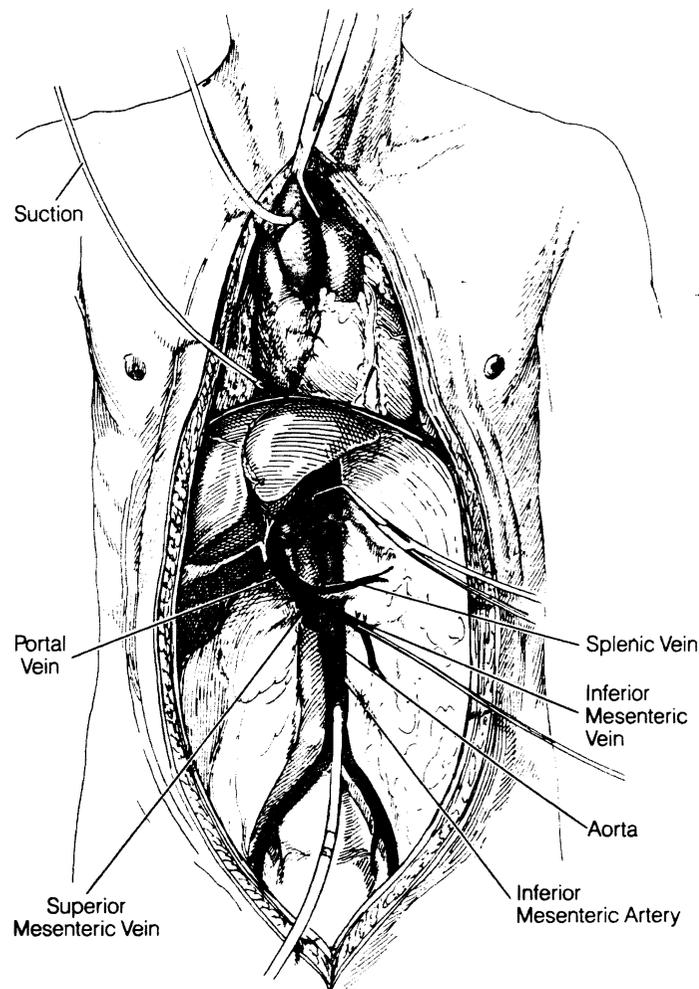
might still prefer to complete these maneuvers preparatory to in situ perfusion.

During such preliminary dissection, however, undetected periods of ischemia may occur, as individual vessels of the kidneys or liver are occluded during their skeletonization. A further disadvantage is that the lengthy operation can be dangerous in unstable donors. Finally, this preliminary dissection is so time-consuming that the participating thoracic surgeons may be delayed for hours. Consequently, in our opinion, dissection beyond that shown [see Figures 2 and 3] is neither necessary nor desirable for removal of the kidneys or liver.

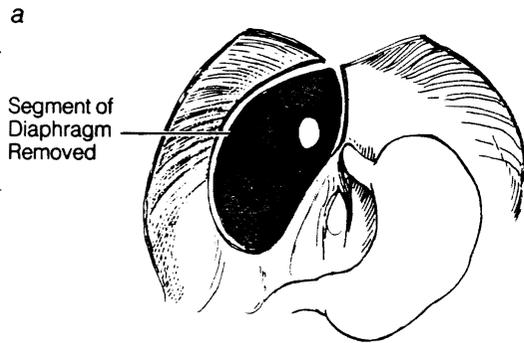
After the minimal dissection, effective circulation is terminated by cross-clamping the aorta at the predetermined levels [see Figure 4]. The cardiac team then proceeds with removal of the heart or heart-lung as expeditiously as possible. The heart is

core cooled with a potassium-rich cardioplegic solution via a cannula inserted into the ascending aorta. Blanching of the heart and cardiac arrest from the cardioplegic infusion occur within a few seconds. At the same time, the systemic venous inflow is discontinued by bleeding the inferior vena cava into the pericardium. However, if the cardiac surgeons insist on cross-clamping the inferior vena cava within the pericardium, the vena cava must be vented into the lower abdomen in order to prevent venous hypertension.

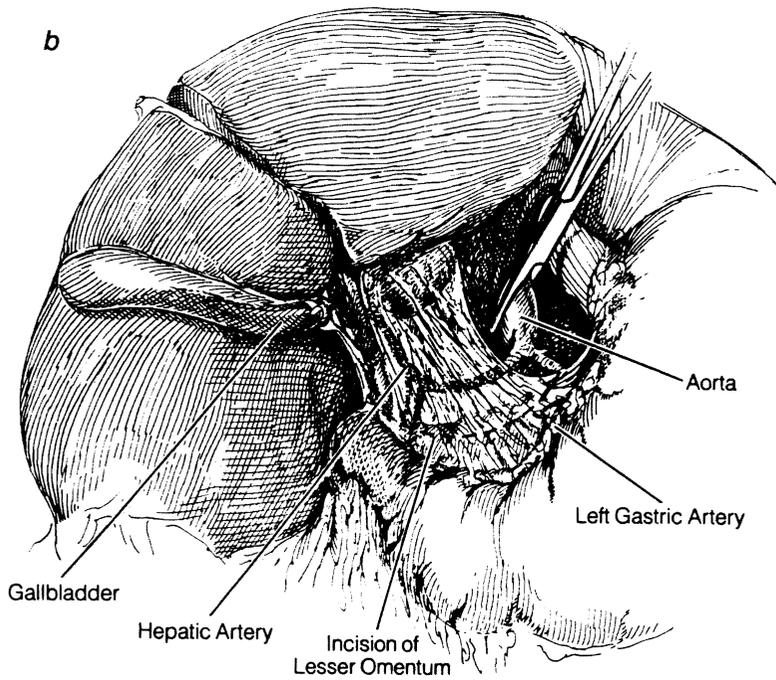
Most cardiac teams require five to 10 minutes from the onset of the cardioplegic infusion to remove the heart. However, as soon as the heart team has discontinued effective circulation by occluding vena caval inflow or by cross-clamping the ascending aorta, the previously encircled aorta is cross-clamped at the diaphragmatic level [see Figure 4]. Infusion with cold fluid is begun through both the inferior mesenteric (portal) cannula and the terminal aortic cannula [see Figure 4]. Thus, the liver is blanching and cooling while the cardiac team is completing removal of the heart. The liver is not dissected further until it becomes palpably cold and free of blood. The kidneys participate in the perfusion and cooling process.



**Figure 4** The aorta is cross-clamped at the diaphragmatic level at the time of rapid infusion.

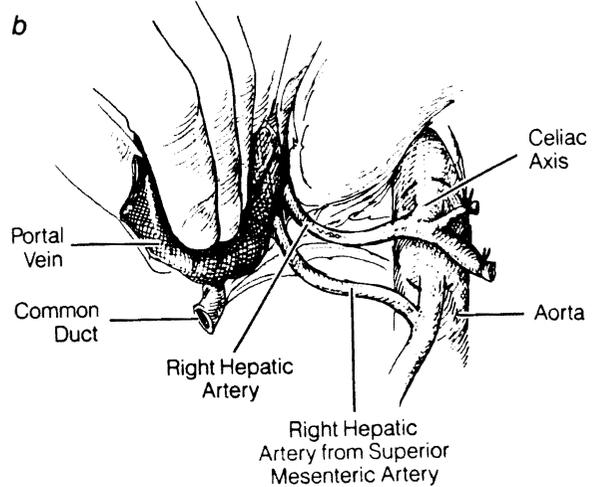
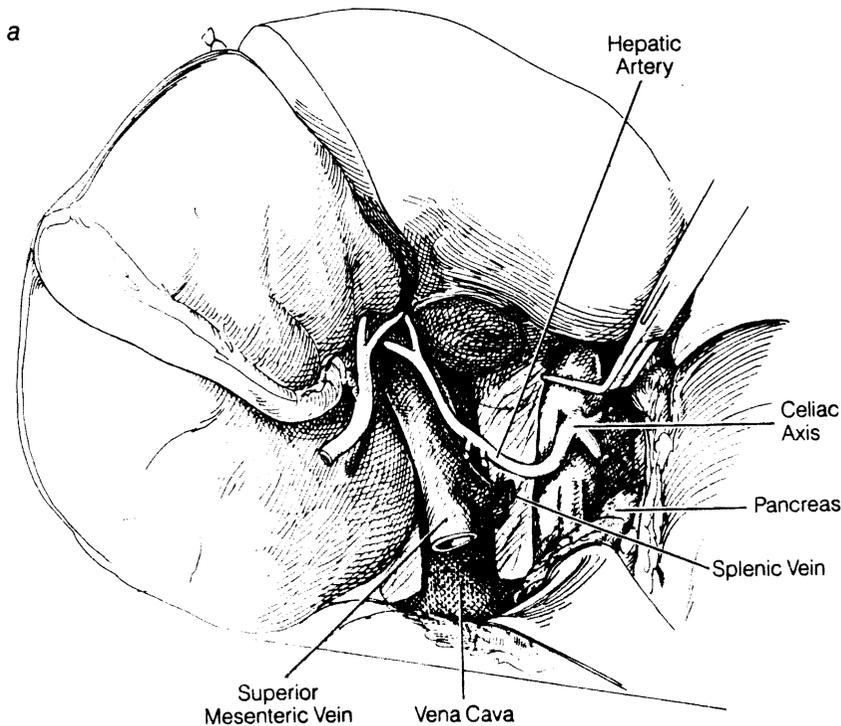


**Figure 5** A patch of diaphragm surrounding the suprahepatic inferior vena cava is removed with the liver (a). Approach to the hepatic hilar structures is made in a bloodless field (b).

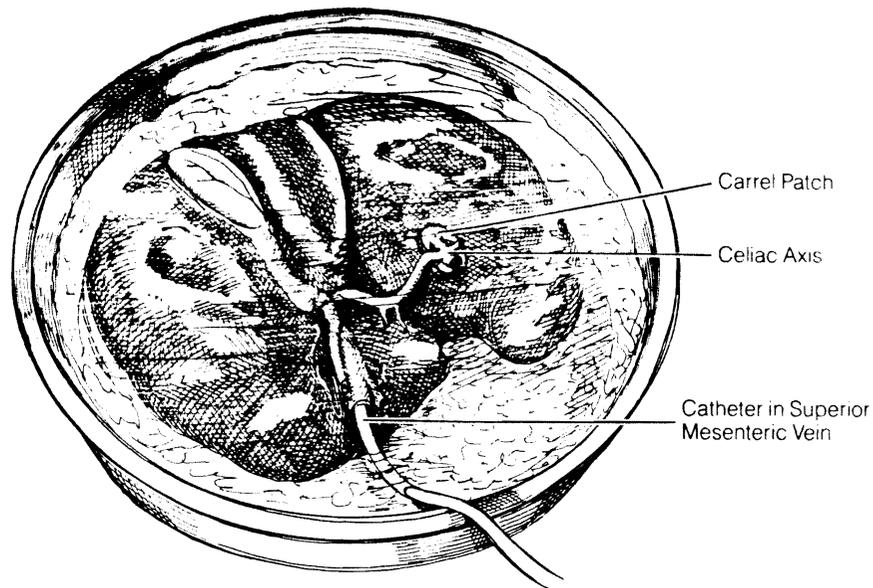


After the liver is cold and the heart has been removed, the liver is removed in a bloodless field while the cold infusion is continued. Above the liver, a patch of diaphragm is removed around the lumen of the suprahepatic inferior vena cava [see Figure 5]; the surgeon dissects the hepatic hilum by cutting or ligating the main branches of the celiac axis as far as possible from the parent trunk [see Figure 5]. By doing so, and especially by

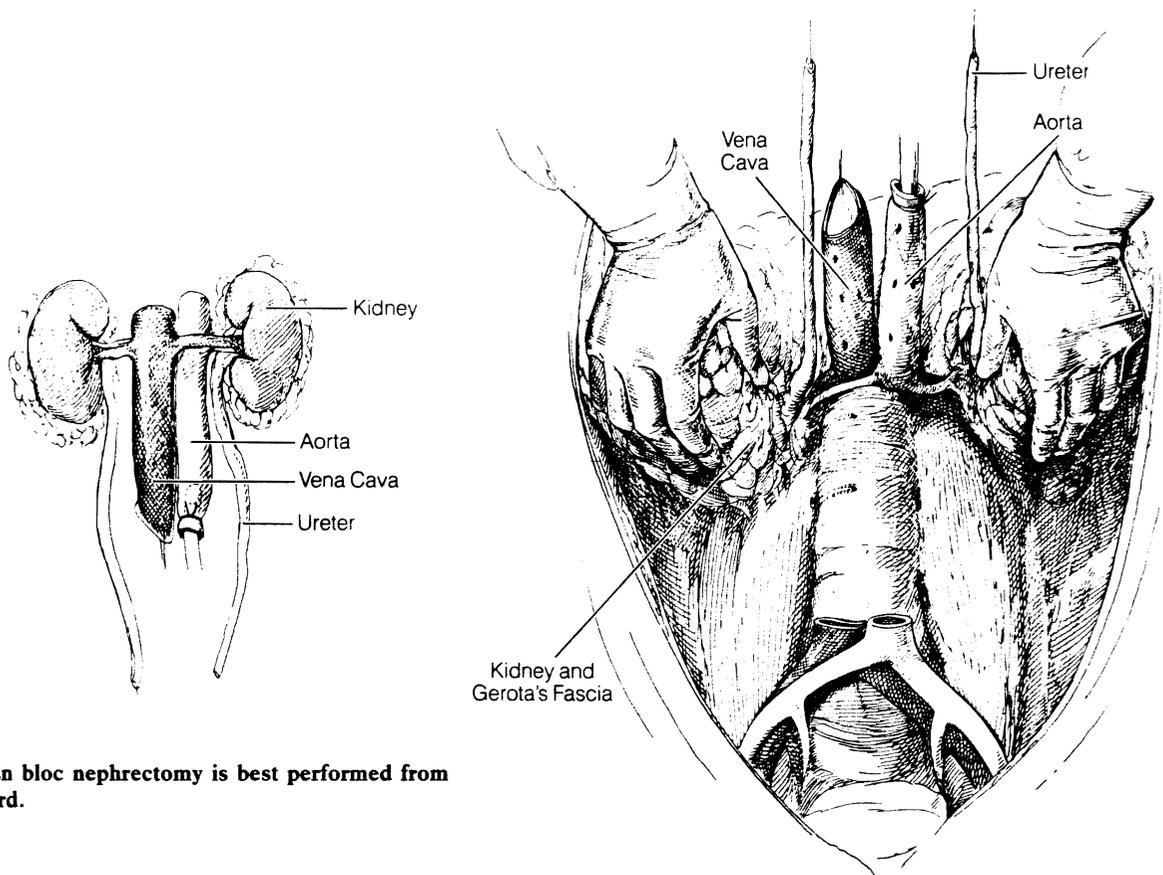
dividing the gastroduodenal artery, the portal vein is uncovered. It is followed inferiorly to the junction of the superior mesenteric and splenic veins, which are cut [see Figure 6]. The area posterior to the portal vein must be inspected carefully, for it is here that an aberrant right hepatic artery originating from the superior mesenteric artery is most commonly found [see Figure 6]. The originating vessel (or vessels, in the case of an aberrant right



**Figure 6** Hilar transection completed (a). With the superior mesenteric vein and the splenic vein cut, the portal vein may be folded superiorly with a finger so that an anomalous right hepatic artery may be found posterior to the portal vein (b).



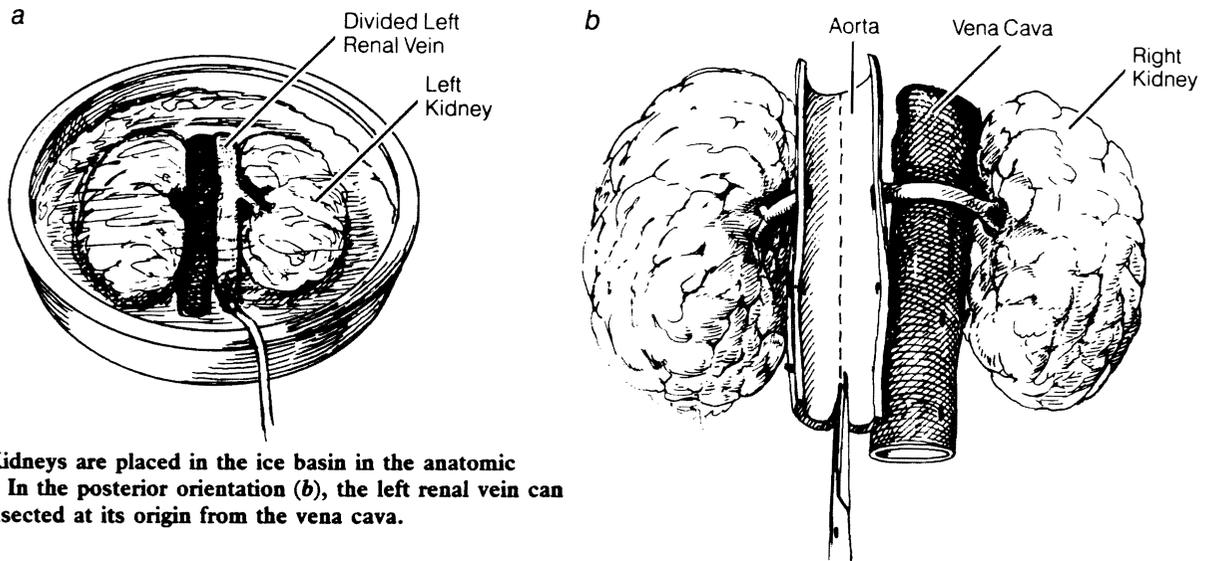
**Figure 7** The aortic Carrel patch and the portal cannula used to infuse chilled Collin's solution are shown in this illustration of an excised liver in an ice basin.



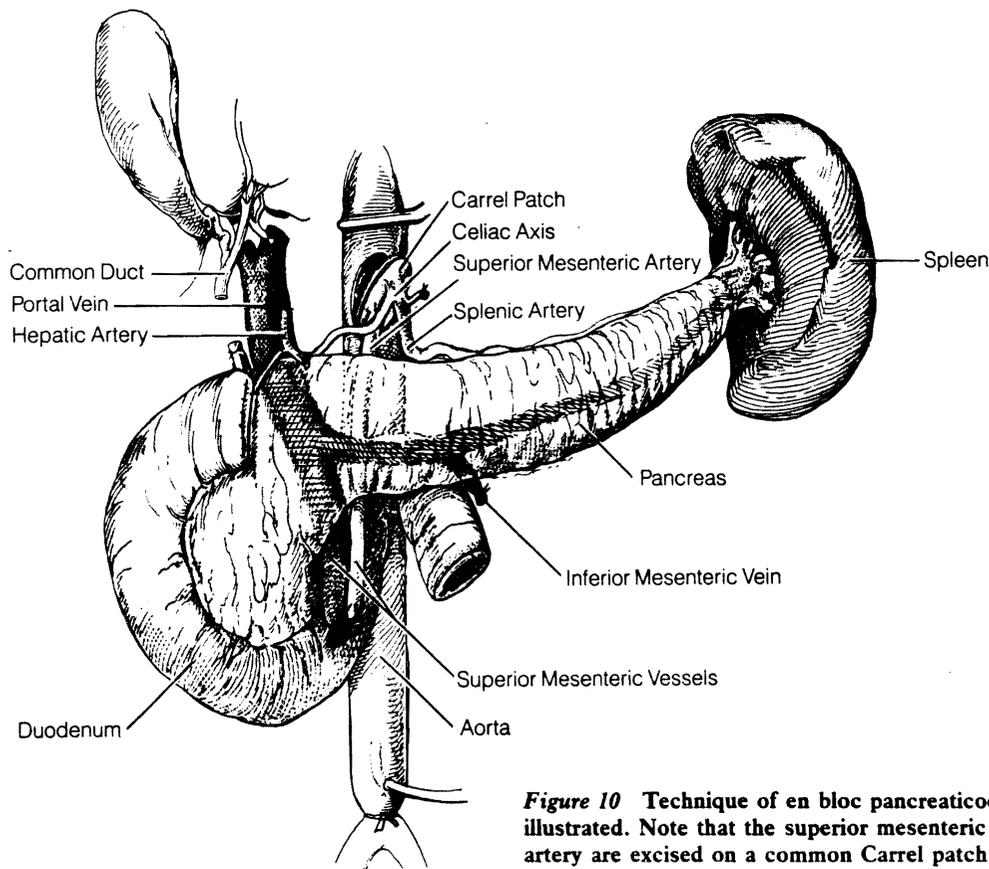
**Figure 8** En bloc nephrectomy is best performed from below upward.

hepatic artery) is traced to its aortic origin and removed with a Carrel patch [see Figure 7]. The liver is excised and placed in a sack filled with Collin's solution and ice slush. A small infusion cannula is placed in the superior mesenteric vein. The liver is then packed securely and refrigerated in a standard ice chest. The organ is transported to the recipient hospital, where it is cleaned and prepared for transplantation at a formal back table procedure [see Figure 7] that takes approximately 30 minutes.

Removal of the cold and bloodless liver requires 15 to 30 minutes, but during most of this time, effective cold perfusion of the kidneys in situ continues through the aortic cannula. With the liver out of the field, both kidneys can be removed en bloc, which takes an additional five to 10 minutes. Removal is best done from below upward [see Figure 8]. After removal, the kidneys are immersed in an ice bath and reperfused with Collin's solution individually or through the aorta. If the kidneys are to



**Figure 9** Kidneys are placed in the ice basin in the anatomic position (a). In the posterior orientation (b), the left renal vein can be seen transected at its origin from the vena cava.

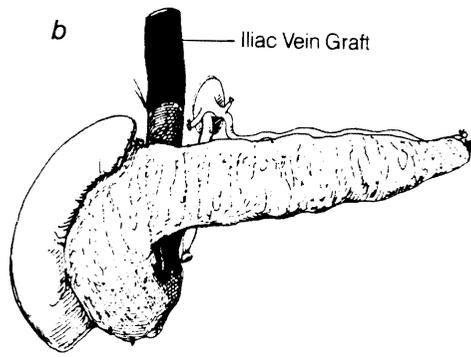
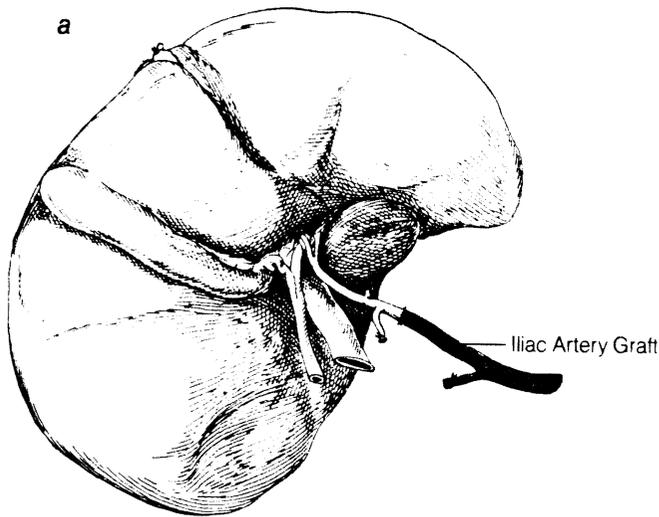


**Figure 10** Technique of en bloc pancreaticoduodenectomy is illustrated. Note that the superior mesenteric artery and celiac artery are excised on a common Carrel patch of aorta.

be separated, the left renal vein is transected flush at its entrance to the inferior vena cava [see Figure 9]. The kidneys are then turned over so that the posterior wall of the aorta is accessible. Inserting one blade of a scissors into its lumen, the surgeon incises the posterior wall of the aorta at the midline. A perfect guide to the line of aortic incision is the row of lumbar arteries. Then, having an internal view of the renal arterial branches passing laterally, the surgeon incises the anterior wall of the aorta

longitudinally from the inside. If continuous perfusion is planned for later preservation, aortic flaps can be fashioned during separation of the kidneys and used for closure so that cannulas need not be placed directly into the renal arteries. Final dissection of the kidneys is performed on a back table at the recipient hospital.

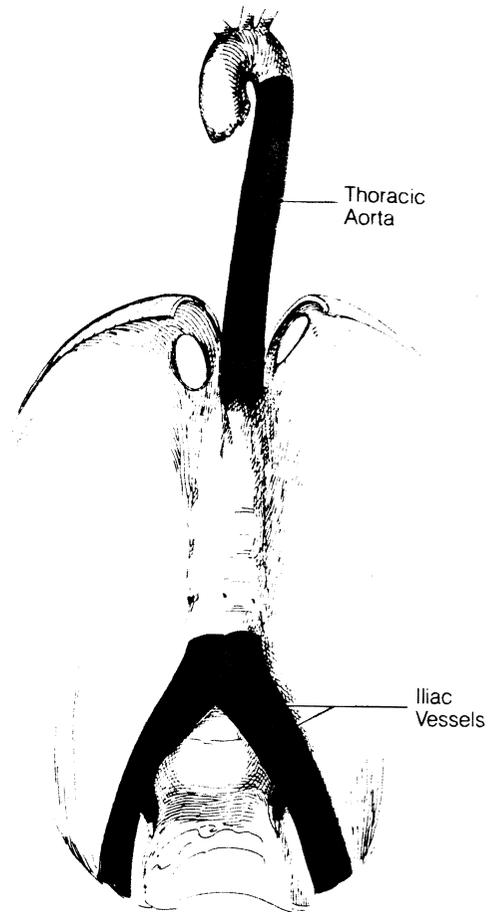
Total or segmental pancreatectomy can be part of the multiple-organ procurement procedure [see Figure 10]. The



**Figure 11** The addition of an iliac artery graft to the hepatic artery and an iliac vein graft to the portal vein of the pancreas graft allows the use of both organs from a single donor.

technique differs in details but not in principle from that of the procedures described (see above). The dissection is carried out in a bloodless field after in situ infusion, and the whole pancreas and duodenum can be removed within 10 to 15 minutes. If the whole pancreas is to be transplanted, a Carrel patch, including the celiac axis and the superior mesenteric artery, can be taken from the abdominal aorta [see Figure 10]. This procedure ensures better vascularization of the pancreas graft, and the natural superior-to-inferior pancreaticoduodenal arterial anastomoses are vascularized from both directions.

To date, whole organ pancreas transplantation cannot be done with orthotopic transplantation of the liver, because both procedures call for retention of the celiac axis and portal vein with the organ. For most diabetics, pancreas transplantation is somewhat of a luxury because of the option of insulin administration. The reverse holds for liver recipients, who do not have a comparable alternate form of treatment. As a result of this conflict, we have restricted whole organ pancreas transplantation to situations in which the donor liver cannot be used, either locally or at other centers. If a multiorgan donor becomes available, the national computer registry is checked. In addition, we routinely call the most active liver transplantation centers to make specific inquiries.



**Figure 12** After organs have been removed and packaged, segments of iliac arteries, veins, and thoracic aorta are routinely removed, as illustrated here.

Improved surgical techniques may make it possible to use both the liver and the whole pancreas. With one such technique, the liver would retain almost all of the portal vein and the short portal vein of the pancreatic specimen would be lengthened with an iliac vein graft from the donor [see Figure 11]. The donor celiac axis, proximal hepatic artery, and superior mesenteric artery would stay with the pancreas. The hepatic artery retained with the liver would be lengthened with a free iliac artery graft. Obviously, many variations of this technique are possible, but it should be emphasized that no such application has yet been successfully tried.

The arteries and veins of a multiple-organ donor can be put to many other uses. After all the organs have been removed and packaged, segments of the remaining iliac arteries and veins are routinely removed [see Figure 12] and placed in a cold tissue culture solution for refrigeration. The thoracic aorta and pulmonary artery may also be harvested under special circumstances. Vascular grafts can be lifesaving in the event of unexpected technical problems in hepatic recipients, approximately 25 percent of whom require portal vein or hepatic arterial homografts. Vascular grafts are also often employed for reconstruction of renal vessels or for other purposes, including potential pancreas vessel reconstruction.

## Discussion

### Principles and Limitations of Current Methods of Organ Preservation

Despite its importance, organ preservation remains the least developed component of transplantation technology. Preservation techniques begin with the intraoperative infusion of cold fluids; the paramount objective is to avoid warm ischemia. Cooling of organs by intravascular infusions of chilled lactated Ringer's solution at the time of circulatory arrest was first introduced into the laboratory for experimental liver transplantation more than a quarter of a century ago. The procedure was promptly applied clinically to the preservation of kidneys and other organs. Such cooling lengthens the duration of organ viability and allows for subsequent application of more sophisticated preservation measures.

Lactated Ringer's solution is low in potassium and nearly isotonic. In 1969, researchers documented that chilled solutions with an electrolyte composition similar to that in cells, such as Collin's solution, extended the permissible time limit of cold renal ischemia beyond that achievable with isotonic solutions.<sup>10</sup> The same effect has been demonstrated in livers.<sup>11</sup> Cardiac surgeons have cooled the heart with various cardioplegic solutions having potassium concentrations of 20 mEq/l or greater.

Employed in so-called infusion-and-slush techniques, high-potassium solutions are currently the only available inexpensive means of preservation of transplant organs. For the heart, liver, and kidneys, respectively, time limits of six, eight, and 48 hours are maximum accepted limits of cold ischemia. Highly sophisticated and costly techniques for continuous perfusion of these organs exist, but they have been widely used only for kidney grafts. The continuous perfusion technique for kidneys as originally described used an asanguinous and oncologically controlled fluid.<sup>12</sup> The method has proved a good one but has not markedly improved the quality of renal preservation in the first 48 hours over that provided by the simpler infusion-and-slush method. In the future, better continuous-perfusion techniques may extend preservation time for all organs.

In the meantime, it is essential to appreciate how unpredictable the outcome of a transplantation can be with any of the currently available preservation techniques. The unknown extent to which the donor has suffered global organ ischemia caused by the processes of injury and dying contributes to this unpredictability. All experienced transplant surgeons have been dismayed at the occasional nonfunction of homografts retrieved from seemingly ideal donors, whereas organs obtained under seemingly adverse conditions may function perfectly. One study has documented this phenomenon particularly well for liver transplants<sup>13</sup>; no correlation could be found between liver recipient outcome and the use of ideal versus less than ideal donors. What is urgently needed is a simple, discriminating predictive technique to assess organ viability before the ruthless biologic test of actual transplantation is performed.

### Medical, Ethical, and Legal Considerations

#### THE RETRIEVAL TEAM

Because the stakes are so high in terms of recipient survival, the technical elements of the organ procurement operation must be constantly reassessed. Much attention is now being given to the specific training of the donor, or retrieval, surgeon. When kidneys were the only organs transplanted, transplant centers often assigned organ retrieval to local surgeons whose experience was limited to only the occasional case. Frequently, the penalty for this practice was a prolonged period of acute tubular necrosis in the transplanted kidney, with the attendant risks and mortality. The enormously increased sophistication of today's multiple-procurement procedures makes this approach undesirable and probably indefensible from the medicolegal standpoint. In addition, it is important to emphasize that surgeons should not delegate to nonphysicians the actual task of excising organs for transplantation from cadaver donors. Today, most transplant centers tend to delegate organ procurement operations to highly trained surgeons with a specific interest and training in transplantation surgery and organ preservation. Only in this way has it been possible for teams from different institutions to retrieve organs from common donors and to work harmoniously and effectively together. This development is a reflection of the maturation of the field of transplantation.

#### THE ROLES OF GOVERNMENT AND THE PRIVATE SECTOR

Less than two decades ago, organ harvesting was an uncommon, hurried, poorly standardized surgical exercise in which kidneys (or rarely, other organs) were rapidly excised from a donor whose heart had just stopped beating.<sup>1</sup> The establishment of irreversible neurologic injury, or brain death, as actual death,<sup>14</sup> has made it possible for surgeons to procure organs from heart-beating cadavers in a well-organized manner. Legislation sanctioning the concept of brain death has been passed in 44 states, and judicial precedent exists in the other six.<sup>15</sup>

Despite these developments, skepticism, fear, and anxiety regarding the concept of brain death persist.<sup>16</sup> Brain death must be clearly and fully explained to the relatives of a potential donor to allay the common fear that life saving measures may be prematurely terminated to gain rapid access to organs for transplantation. This is never the case. The physician in charge of the initial care of the donor is responsible for determining and making the pronouncement of brain death, with the collaboration of experts in the neurosciences. He or she in no way participates in the donation and harvesting procedures. Conversely, the transplant surgeons cannot participate in the determination of death.

The Uniform Anatomical Gifts Act (UAGA), passed by Congress in 1973, has been adopted in some form in all 50 states.<sup>17</sup> This act states that organ donation is a voluntary gift made by either the donor himself or the family. The UAGA does not in-

clude the concept of presumed consent, whereby organs may be removed automatically unless the next of kin objects. Presumed consent has been practiced in many European countries with some success, and strong ethical arguments have been advanced in its favor.<sup>18</sup> The concept of presumed consent has not gained a foothold in American transplantation.

Despite passage of brain-death legislation and of the UAGA, there is still an acute shortage of cadaveric renal and extrarenal organs, which has been aggravated by the burgeoning success of transplantation. Several factors contribute to this shortage. Some physicians do not wish to face the failure implicit in the death of their patients, or they do not want to further burden a grieving family by requesting donation, or they are aware of certain religious taboos about organ donation, or they unrealistically fear legal recriminations.

The Surgeon General of the United States has made several recommendations for solving these problems, including systematic public education and education of physicians, nurses, and paramedical personnel; recruiting support from the religious community; and sharper delineation of the exact conditions to be met for a pronouncement of brain death.<sup>19</sup> Another strategy to increase organ donation has been to encourage the signing of donor cards and other forms of living wills.<sup>20</sup>

The organ shortage has prompted a new kind of legislative initiative called required request. Required-request laws have been passed in almost half of the states. These laws mandate that each hospital systematically approach the families of all patients who die under circumstances that might make solid organ or tissue donation possible. With such laws, physicians and hospital staff are protected from charges of callousness for asking a grieving family for donation, they are relieved of the fear of legal recrimination, and they can work within an organized administrative channel. If the required-request laws do not increase the supply of organs, it is conceivable that further legislation mandating the application of presumed consent may be considered.

In 1984, Congress enacted legislation authorizing a task force to study issues in organ procurement and distribution and provided for the creation and funding of the United Network for Organ Sharing. UNOS was awarded a contract by the federal government to operate a computer-matching system to aid in placing renal and extrarenal organs in a systematic way and to ensure equitable allocation of organs throughout the country. In addition, UNOS is to keep careful data on all harvested organs to analyze and define patterns of organ procurement in the nation so that resources for future development can be better allocated. In the distribution of extrarenal organs, UNOS acts in an advisory capacity to the organ procurement agency managing a specific donor by supplying a prioritized list of acceptable recipients, but the final choice of recipient center is left to the local procurement agency. Each transplant center must control its own standards for giving priority status to its patients on the waiting list for organs. In the allocation of extrarenal solid organs, priority is commonly given to recipients within the region of procurement. Within the region, urgency of need should have the highest priority, and for organs leaving a region, urgency of need also is a key factor. In contrast, UNOS also has a priority system for placement of all shared kidneys in the United States.

If a kidney cannot be used in the region in which it is procured, the organ center at UNOS sends it to that region in the country having a recipient with the best priority score based on time waiting, antigen match, degree of sensitization, and other considerations. The details of the UNOS system of equitable allocation of organs were worked out in field trials in Pittsburgh<sup>21,22</sup> before adoption nationally.

It is interesting to speculate how this system will change in the future, as more surgeons are trained in extrarenal organ procurement, as regional centers proliferate, as involvement of personnel at the new centers increases, and as additional demands for equitable allocation of organs are made on the distribution network. Procurement surgery will probably be done by locally trained expert surgeons, thus obviating the need and decreasing the expense of having two or three separate procurement teams visiting from distant regions. As more powerful immunosuppressive techniques are developed and tissue typing and matching become better understood, smaller organ procurement regions in the country may coalesce into larger and more centralized territories to increase the pool of potential local recipients and decrease the time that an organ must be stored prior to placement. Cold ischemia time would be shortened and survival might improve. Today, the urgency that results from poor organ preservation techniques places a real strain on any organ distribution and sharing system covering a large region.

In parallel with the rapidly growing success of organ transplantation, there has been an increase in federal and state government interest in regulating transplantation medicine. We agree that the government should collaborate with the transplantation community in developing new health policies; however, over-regulation could stifle the orderly growth and progress of transplantation. Attempts to limit transplantation of extrarenal organs to existing centers may hinder rather than foster progress in the field and should be resisted. The emphasis should be on constructive collaboration, not domination of what must primarily remain an effort by transplant surgeons. For example, media coverage of transplantation has led the public to believe it is a fully established science, ready for mass clinical application, and this gross misunderstanding of the complexity of the problems involved has generated ambitious proposals for national organ retrieval and sharing legislation that ignore the fact that it will be at least 10 to 15 years before organ preservation technology is sophisticated enough to meet the goals the government is setting.

There is also a danger that public misconceptions about transplantation medicine will result in government efforts to regulate the criteria for patient treatment. Political guidelines must not be allowed a role in judging a candidate's suitability for transplantation. Physicians cannot ethically accept any but strict medical criteria in selecting organ recipients.

Since the early 1960s, knowledge in the field of transplantation medicine has grown almost exponentially. The tremendous potential of this field continues to depend on broad research toward solutions to a wide variety of problems in the laboratory and at the bedside, as well as on resolution of the issues and controversies that transplantation has generated for the public and the medical community.

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