Development and Organization of a Multiple Organ Transplantation Program

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Multiple organ transplantation has come of age. Indications are that it will continue to grow, if not flourish. The complexity of modern surgical care, its multiperson dependency, and the need for the surgeon to retain knowledge and involvement with his patient's care and problems are nowhere more evident than in multiple organ transplantation. Each organ presents its own associated challenges, the prime solution of which lies with a skillful and dedicated surgeon; but with all organs there are challenges of expectantly waiting patients, housing during the wait and for postoperative observation, procurement, erratic scheduling of the operating room, nursing, social service, immunosuppression, immunopathology, interest of hospital public relations and of the news media, and perennial care. This report concerns the growth and development of the multiple organ transplant program at the University Health Center of Pittsburgh and describes some answers to the challenges presented.

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MULTIPLE ORGAN TRANSPLANTATION has come a long way and continues to grow. Sixty-nine per cent of our patients receiving cardiac transplants survive 3 years. The 3-year survival of those receiving livers is almost the same, and 90% of patients receiving kidneys can expect to live this long. In the case of kidneys, patient survival is better than graft survival, which is 75% at 3 years.

Although renal transplantation was first performed in Pittsburgh in 1963 and sporadically thereafter, the modern program began in 1977, revived by the Urology service. A Transplant Organ Procurement Foundation was established and the program was funded by Medicare under Title XVIII of the Social Security Act. In 1980, 45 kidneys were transplanted, all except two from cadavers. Two hearts were transplanted in that year, reviving a premature start of cardiac transplantation that had been made in 1968 but then abandoned for more than a decade. Immunosuppression at that time included azathioprine, prednisone, and antithymocytic globulin.

In 1981 hepatic transplantation was begun and cyclosporine became available as an experimental drug for livers, kidneys, and hearts. The quantum step forward that occurred with introduction of this drug, probably as much as with any other single factor, was responsible for the growth of transplantation in our own and other centers. In the last 12 months at the University Health Center of Pittsburgh, 160 kidneys, 91 hearts, 11 with lungs, two lungs, 232 livers, and five pancreases were transplanted. The purpose of this report is to describe the development and organization of the program at the Health Center, with emphasis on administrative challenges peculiar to transplantation and our answers to them.

Renal transplantation in the University Health Center was initially performed on the general surgical service. Never very active in the early days of transplantation, the program became inactive and was revived in 1977 on the urological service, under whose impetus and direction organ procurement was organized. As multiple organ transplantation grew, a Division of Transplantation was established to encompass the broader area of transplantation, especially in regard to research and education. Renal transplants are performed about equally by the transplant and urological surgeons, and heart, heart-lung, or unilateral lung transplants are performed on the cardiothoracic service. Separation by organ is valuable for education and research, but so is coordination of effort in the broad area of transplantation. In any community of moderate size,

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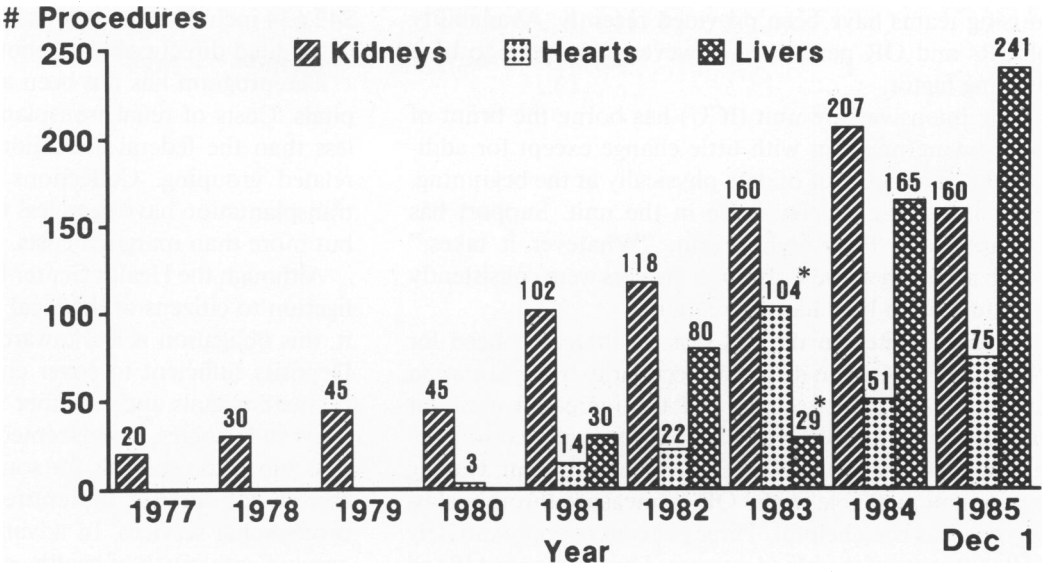

FIG. 1. Transplantation procedures performed at University Health Center of Pittsburgh as the multiple organ program developed. *Hearts and livers are mistakenly reversed for 1983.

there will be sufficient need for renal transplantation to provide for both urological and general surgical services sufficient experience for education and training and to maintain skills. The accepted fact of using multiple organs from the same donor is a strong reason for coordination of services.

Transplantation has grown in the University Health Center of Pittsburgh almost beyond anyone's expectation. As various elements were added, approval was sought from the Trustees and the Administration. This approval was clearly needed in 1980, at a time when the Secretary of Health and Human Services had ruled cardiac transplantation to be experimental, and Trustees of the Massachusetts General Hospital had disapproved a recommendation that cardiac transplantation be performed in that hospital. Our own initial planning and expectations were too small in scope, as were those of administrators and trustees who were hesitant to overcommit until the need was demonstrated (Fig. 1).

The initial crunch, and the most persistent and pressing one, was in the operating room (OR) with Anesthesiology and Nursing Services. Similar problems faced both services. The prime determining factor in transplantation is the incalculably valuable donor organ, obtained from brain-dead, heart-beating donors. Neither procurement nor transplantation operation can be scheduled electively. Most donor organs become available during evening or night hours. Certification of brain death usually is completed during usual working hours, and only after operations have been completed on patients will most operating rooms be freed for removal of organs from brain-dead donors. Hence organs arrive for transplantation in late evening. More donors seem to be offered on weekends. In one way, performance of transplantation in odd hours is desirable because it results in more complete around-the-clock use of costly hospital resources, but more anesthesiologists, nurses, and staff are required.

The first response to this problem was to hire and train more personnel. Novelty of the work is an attraction to personnel, but its complexity requires that additional time be spent in training. The physical and mental demands of operations that may extend for most of a day do not appeal to everyone, and risk of acquiring hepatitis is greater in this field. The pace and demand of the work, and the longer and odd hours result in a greater turnover of some personnel.

Added to these problems is the urgency of operation, even in the case of a kidney, where cold ischemia is tolerable for 48 hours. The shorter the ischemic interval, the better the transplant will function. Our desired limit of 4 hours for a heart is largely consumed in transportation from most donor sites. Surgeons easily can imagine the consternation in the operating room when the supervisor is asked to add to the regular schedule an urgent operation on a donor, plus a cardiac or cardiopulmonary, liver or pancreatic, and two renal transplants—each in a different patient. This would not be possible without cooperation and accomodation of surgeons on the involved services and, more importantly, on other surgical services.

Expansion of transplantation occurred at the time when more operations were being performed on ambulatory patients. This freed hospital beds for longer stays required for transplantation services, but this did not lessen the burden on ORs. A partial answer to the problem was opening a new OR for ambulatory patients and setting aside one room for emergency trauma and overflow when the nocturnal work of transplantation extends into the normal working hours. Three additional on-call surgical

nursing teams have been provided recently. Availability of ORs and OR personnel, however, continues to be a limiting factor.

The intensive care unit (ICU) has borne the brunt of the growing program with little change except for additional personnel. Out of date physically at the beginning, few changes have been made in the unit. Support has exemplified a Pittsburgh slogan, "Whatever it takes," which arose when the Pittsburgh Steelers were consistently winning, often by a narrow margin.

Closely related to the OR was an increased need for blood. There were no demands peculiar to transplantation except for a larger volume and the increased need for platelets and clotting factors for patients with clotting abnormalities who are receiving a hepatic transplant. Having equipment available in the OR to measure thromboelastograms has been helpful. Three per cent of approximately 150,000 units of the blood processed by the Central Blood Bank of Pittsburgh is used for hepatic transplantation. Although in the past hepatic transplantation has required as many as 200 units of whole blood, the average use at present is approximately 20 units each of packed red cells, plasma, and platelets. This use presented a challenge and resulted in a greater use of blood than in other centers, but the effect has not been catastrophic to a highly supportive and efficient organization.

Somewhat similar problems, caused by odd hours and increased volume of work, were faced by immunopathology. Tissue typing and crossmatching for antigens other than ABO of the red cells had not usually been done at night, but now is required. Additional personnel have been hired and more space is needed, for instance, to preserve sera for retrospective crossmatching and determination of reaction to a panel of antigens.

Next in importance was a financial challenge. The Social Security Act provided payment to hospitals only for expenses directly related to renal transplantation, leaving to self-paying patients and other insurers many of the indirectly related costs of hospital care for renal transplantation. Surgical fees also are paid for renal transplantation. For transplantation of nonrenal organs, policies vary among Medicare, Medicaid in different states, and different insurers, but coverage is more common now than 5 years ago. Most insurers require their approval in advance. The hospital's financial officer has determined whether the patient is eligible for benefits, as from Medicaid, and whether the insurer will pay.

Transplantation is still a costly procedure. We have learned to do the procedures well but have not yet learned the most economical way. Average hospital charges for an adult are $35,000 for renal, $92,000 for cardiac, and $115,000 for hepatic transplantation. For comparison, the average hospital charge for coronary artery bypass is $42,634 including the medical work-up, $26,654 without it. Audited direct costs are about 61% of these charges.

The program has not been a financial loss to the hospitals. Costs of renal transplantation have been slightly less than the federal allocation based on diagnostically related grouping. Collections for cardiac and hepatic transplantation have been less than fully allocatable costs but more than marginal costs.

Although the Health Center Hospitals recognize an obligation to citizens of the local community that supports it, this obligation is less toward residents of other states. Deposits sufficient to cover charges have been required by the hospitals and, as other services provide consultations and charges, it has seemed best for the surgical business office to establish for some self-paying patients an escrow account for the entire amount of hospital and professional services. In advance of what appears to be coming with much of health care, and because extrarenal transplantation has not been universally performed, we (along with the hospitals) have been asked to contract with health maintenance organizations for transplantation services. This has been handled by the surgical business office.

A major cause of complications and death in immunosuppressed patients is infection. Of the various consultants, we have relied most on those from the Division of Infectious Disease. Infections in transplanted patients are different. Viral diseases with minor symptoms are common and often progress rapidly. Prospective monitoring serologically for toxoplasma and by culture for cytomegalovirus, herpes, and Epstein-Barr virus has been helpful. Legionella presents a risk that is peculiar to immunosuppressed patients. Legionella is present in many water systems. It was cultured from two-thirds of our water fixtures 2 years ago. It can be controlled by superheating or by chlorination, but its presence must be monitored when immunosuppressed patients are exposed. After superchlorination, the fraction of positive cultures from our water fixtures fell to 1%. Although there is no evidence that Legionnaires disease has spread *via* drinking water, cardiac patients are provided with bottled water. Showers and exposure to aerosolized tap water are interdicted.

Organ procurement is an integral part of, and is specific for, transplantation. Virtually all procurement agencies were founded on renal programs, funded by the End Stage Renal Disease Program of Medicare. The kidney is the most commonly transplanted organ nationwide and will probably remain so. In the Health Center as the multiple organ transplantation program grew, expenditures for kidney procurement fell from 100% in 1980 to 31% in 1984 (Fig. 2), the difference due to increased procurement of hearts and livers throughout the nation, often by unscheduled jet aircraft. Local corporations have been help-

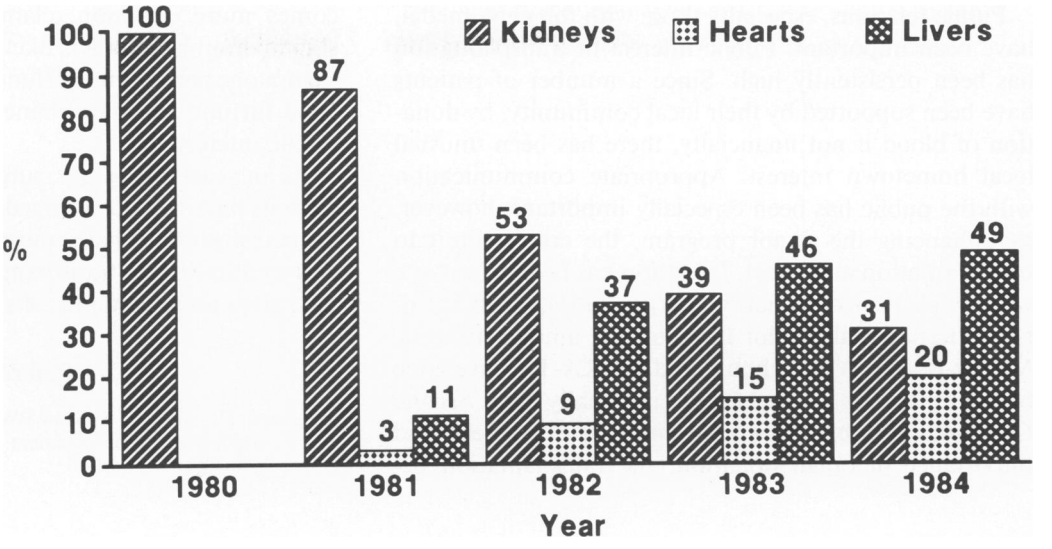

FIG. 2. Expenditures for organ procurement as the fraction for kidneys declined, due to increased transplantation of nonrenal organs (January 1, 1980 to December 31, 1984).

ful in making planes available when not otherwise in use. The need and use of donors is nationwide and procurement must be a national effort.

With the exception of hearts, organs can be transported safely anywhere in the contiguous United States, sometimes even *via* commercial airlines in the case of the kidney. Effective networks for matching and sharing of kidneys have been developed by several regional procurement foundations. Similar programs exist for nonrenal organs under direction of the United Network for Organ Sharing and the National Association of Transplant Coordinators. The Congressional National Organ Transplant Act of 1984 directed that an Organ Procurement and Transplant Network be established to maintain a list of individuals who need organs, to establish a national system to match organs and individuals (especially those who are difficult to match), to assist in distribution of organs that cannot be placed in the service areas of the organizations, and to adopt and use standards for acquisition and transportation. Designation of one national network or coordination of several networks is needed for most effective use of this national resource.

Procedures have been described for procurement and safe preservation of multiple organs from the same donor.[1] These techniques need to be standardized, as much as operations done by different surgeons can be standardized, in order to use and preserve safely all organs and even to permit a team to transplant an organ procured by another team. In most other centers, it is unusual for all organs to be implanted in the same hospital, but it is usually more economical to do so.

Important elements of the program pertain to ambulatory care. Because of immunosuppression, patients must be closely followed, especially soon after operation and discharge from the hospital. The importance of minor symptoms and the uncertainty in the minds of patient and doctor lead to frequent, often unscheduled, visits. The expense of cyclosporine and prednisolone add to the patient's problem. Surgeons are responsible for most of the ambulatory care and follow-up with consultations as needed. This would not be possible without the assistance of nursing specialists and nurse coordinators. Nonetheless, the problem of extra-hospital care of the large group of immunosuppressed patients is almost overwhelming.

Whether at home or in Pittsburgh, patients and families must be available on short notice if a suitable donor organ becomes available. Most candidates reside at home; some will need to carry portable paging units. Patients need a great deal of emotional support because of the severity of their illness and the uncertainty of their future. Social Service has been helpful and instrumental in providing support and helping patients and families with social aspects of their disease. They have been able to obtain special consideration from USAir for patients who need frequent or emergency air transport, and they have served as an advocate for patients who are unaccustomed to negotiating with insurance organizations for coverage.

Early in the development of the program, housing for patients and families presented a challenge. Impressed with the advantages of Ronald McDonald House for children, especially those with cancer requiring prolonged care at Children's Hospital of Pittsburgh, and with the help of interested friends and corporations, a Family House was established. Two adjacent houses in the neighborhood of the Health Center were purchased, renovated, and joined to provide 31 bedrooms, living room, and a do-it-yourself kitchen for use by patients or their families. Both financial and emotional stresses thereby have been alleviated. H. J. Heinz Company is considering providing assistance in similar projects at other centers.

Public relations, especially those with the news media, have been important. Public interest in transplantation has been persistently high. Since a number of patients have been supported by their local community, by donation of blood if not financially, there has been unusual local hometown interest. Appropriate communication with the public has been especially important, however, by enhancing the donor program, the critical limit to transplantation at present. Donation has been seized as a worthwhile project by national organizations such as Rotary International, Junior League, and, among students, Mortar Board. Westinghouse and KDKA-TV have gone beyond the news to produce the nationally aired *Second Chance* as a public service to emphasize the need and importance of organ donation. As transplantation becomes more common, clamor for news by reporters should diminish, but it is likely that donation of an organ to turn one person's misfortune and loss of life to another's good furtune and new chance for life will always be of public interest.

As an academic center, surgeons and many of the consultants have been challenged by the many opportunities for investigation. That is our greatest challenge, to assure that multiple organ transplantation, which offers hope today, gives more certainty of success tomorrow.

Reference

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Discussion

DR. ARNOLD G. DIETHELM (Birmingham, Alabama): I would like to thank Dr. Bahnson for the opportunity to review his manuscript and to think about some of the many features that he put forth to us today.

I would like to comment on just a few aspects of the paper. First, if the allograft rejection process could be controlled by whatever means, cyclosporine or a new drug not yet identified, the lack of organs would become the major obstacle to transplantation in the treatment of patients with renal failure.

There are at least three important aspects to the present organ shortage. One is the lack of well organized procurement programs. This deficiency is at the local, statewide or multistate programs. The local–state program will always be necessary regardless of national organ procurement programs.

The second obstacle is the need to improve patient education just as Dr. Bahnson indicated, and the third obstacle is a little bit painful to mention, but it is physician apathy. It is the apathy of the physician who does not wish to be in the position of having a deceased patient and having to make a decision to ask the patient's family for permission to turn off the ventilator.

Fortunately, none of us has to do this very often, but, if all of us would deal with this issue when it occurs, the number of potential organs would increase.

Dr. Bahnson and his colleagues have directed their attention towards multi-organ procurement. This is an important concept because at present most of the emphasis has been on the removal of kidneys. However, if one can remove the kidneys, why not the heart, the liver, the pancreas, bone, etc., as Dr. Bahnson has clearly indicated, recognizing that age may preclude some patients from donating certain tissue and organs such as hearts, aortic valves, etc.

The Foundation for a strong organ procurement program now, and I believe for the foreseeable future, will remain in the area of renal transplantation. That is where the need is, and that is where the patients are. If one has a strong renal procurement program, the procurement of other organs will follow.

I would like to show two slides, if I may, to indicate our own development in this area.

(Slide) In our own institution we have developed the Alabama Regional Organ Bank. This program interacts with 45 different hospitals in several states.

You can see that in the calendar year of 1982 we procured eight hearts and in 1985, as of November 1, we procured 39 hearts. We procured three livers in 1983, two in 1981, and one in 1985. We obtained aortic valves for cardiac use in 1983—65, 1984—113, and 1985—168. In addition, various pieces of bone etc. from the iliac crest were also obtained. Thus, the organ bank is no longer a renal organ procurement program, but, in fact, it is a multiorgan procurement program.

Our organ bank interfaces with a number of extrarenal teams. As you can see, Pittsburgh has visited Alabama on eight different occasions. Surgeons from Memphis, Medical College of Virginia, Nashville, Dallas, Duke, Houston, Louisville and Iowa City have also interacted with our organ bank.

It is clear that now we are no longer really talking about renal transplantation but multiorgan procurement and that is clearly the key for the growth and development of transplant programs around the country.

I would like to ask Dr. Bahnson and colleagues two questions. First, you mentioned rather briefly the upper time limit for cardiac ischemia was 4 hours. How comfortable are you with 4 hours? Do you feel that you can exceed that time limit? I realize the shorter the ischemic time, the better, as you indicated.

The second question is: How concerned are you about the young heart beating cadaver donor candidate who requires a catecholamine support drip, in regard to its effect on cardiac performance after transplantation?

DR. E. STANLEY CRAWFORD (Houston, Texas): Dr. Bahnson and his associates are to be congratulated for developing a multiorgan transplant service to maximize use of available individual organs to benefit the maximum number of patients. At this time, based on a theoretical 5-day work week, they are procuring, harvesting, and transplanting about two organs each day, half kidneys and half livers, hearts, or heart and lungs. Most would agree that this is a Herculean effort that would consume the time and energies of most; but this group not only has a good in-hospital training and research program, but has been most generous in sharing their experiences with others who desire to introduce or improve this field at their own hospitals.

Each individual member of the team deserves to be congratulated for his part in this effort; but I think that Dr. Bahnson deserves special recognition for his vision for such a progam and his administrative and political skills in putting things in place. Consider the problems he may have had in selling the idea to the university, mobilizing the cooperation of other departments such as anesthesia, blood bank, cardiology, nephrology, and immunology. It could have been tough going when he asked his other surgical colleagues (orthopedists, general surgeons, neurosurgeons, *etc.*) to give up operating time as well as recruiting necessary talent. The ultimate was getting community acceptance and cooperation. This was an enjoyable presentation, and I think that it will prove correct to state that the success of this effort will be the crowning achievement in what already has been a distinguished career for Dr. Bahnson.

DR. JOHN C. MCDONALD (Shreveport, Louisiana): These are exciting times in transplantation, and we are indebted to Dr. Bahnson for bringing to our attention the enormous logistic problems in the development of a really major multiple organ transplantation program. You can imagine, however, that as nonrenal organ transplantation procedures become ev-