

The Rapid Development of Solid Organ Transplantation in North Carolina

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The first successful solid organ transplant between two individuals occurred in Boston in 1954 involving a living-related kidney transplant between twin brothers. The ensuing three decades were filled with dramatic stories of basic science and clinical research resulting in the successful performance of transplants, mostly with cadaver (brain dead) donors, involving the liver, pancreas, heart, heart-lung, and finally isolated lungs. Despite these successes, the overall survivals were largely measured in months and the procedures were only available in a select few transplant facilities. Clinical transplantation did not become a reliable therapy until the work to develop effective immunosuppressant medications resulted in the release of Cyclosporine in 1982. Thereafter, an explosion of activity occurred, with transplant centers opening at many major academic medical centers across the country. The clinical results achieved led transplantation to become standard therapy for end-organ disease of the organs noted above. At the present time, there are 260 transplant centers in the United States, which encompass a total of 835 individual transplant programs (Table 1).

Transplantation in North Carolina

North Carolina followed the national trend with the development of transplantation programs at each of the academic medical centers. Duke University and the University of North Carolina at Chapel Hill led the way, establishing programs in all transplantable organs. Subsequently programs in selected solid organs have been developed at East Carolina University (kidney), Wake Forest University School of Medicine (kidney,

pancreas, heart) and the Carolinas Medical Center in Charlotte (kidney, heart, liver and pancreas).

At the University of North Carolina School of Medicine-UNC Hospitals, solid organ transplantation began with kidney transplantation in 1968. The heart transplantation program was founded in 1986, and was followed in rapid succession by lung transplantation in 1990, heart-lung transplantation in 1991, liver transplantation in 1991 and pancreas transplantation in 1994. In addition, UNC has further developed the expertise to perform pediatric transplantation in each of the individual organ programs (Table 2).

The Effect of Transplantation on Medical Education

The rapid development of these programs has led to dramatic changes in the training of medical students, residents, and subspecialty fellows. Medical students now learn the basics of transplantation immunology

Table 1.
Transplant Programs by Organ in the United States
Medical Centers with Transplant Programs – 260

Organ	Number of Programs
Kidney	245
Liver	122
Pancreas	169
Heart	141
Heart-Lung	82
Lung	76
Total	835

Source: Modified from UNOS Data (www.unos.org).

Table 2.
Numbers of Procedures by Transplant Programs
at UNC Hospitals, 1968 – present.

Organ	Adult	Pediatric
Kidney	941	114
Heart	196	31
Heart-lung	10	3
Lung	225	24
Liver	457	85
Pancreas	3	3
Total	1,832	260

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during their basic science years and are exposed to clinical transplantation during their clerkships. Residency training programs in internal medicine, pediatrics and general surgery, at least at academic centers with transplant programs, now include education and experience with transplantation. In internal medicine and pediatrics, residents (and attending physicians) must learn to care for patients with end-stage organ disease, including when to refer patients for transplantation, and the basic care of these patients post-transplantation when they present with transplant complications (infections, renal failure, and malignancies), in addition to standard health maintenance for the common side-effects of the medications, including hypertension, hypercholesterolemia and diabetes mellitus. General surgery residencies at academic medical centers often include separate clinical services for abdominal transplantation through which the residents rotate.

At UNC-CH, Abdominal Transplantation is now a separate Division within the Department of Surgery with a separate clinical service, a full complement of residents assigned to the service, a transplant fellow, and four attending surgeons, all of whom have completed Abdominal Transplantation Fellowships. General surgery residents gain experience in thoracic transplantation when they rotate on the cardiothoracic surgery service. Our cardiothoracic surgery residents assume responsibility for the heart, heart-lung and lung transplant patients as part of their routine duties. Our faculty at UNC includes three cardiothoracic surgeons who have completed Thoracic Transplantation Fellowships.

Many of the common fellowships now must include experience in transplantation. Adult and pediatric cardiology, gastroenterology, nephrology, infectious diseases, oncology and many other fellowship training programs must now educate their fellows in the care of their specialty-related transplants. In addition, there are now subspecialty fellowship programs specifically in heart failure and cardiac transplantation, hepatology and liver transplantation, and renal transplantation. In surgical training, fellowships have been established in abdominal transplantation, covering liver, kidney, pancreas and most recently intestinal transplantation, and in thoracic transplantation covering heart, heart-lung and lung transplantation. Indeed, medical societies have been founded which focus specifically on transplant medicine. The most prominent are the American Society of Transplant Physicians, the American Society of Transplant Surgeons and the International Society of Heart and Lung Transplantation. In all, an entire new body of knowledge has been added to medical education, largely within the past decade.

Just as medical schools and post-graduate training programs have had to assimilate this new body of knowledge, hospitals have had to evolve as well. All major transplant hospitals must have the appropriate staff and laboratories, as well as the availability of operating rooms, anesthesiologists and trained operating room personnel to perform the transplants and care for the patients afterward. The individual transplant programs are required by Medicare and many insurance programs to ensure thorough evaluation of potential candidates in order to select patients who will be most likely to benefit from the scarce

resource of donor organs and the expensive and complex therapy inherent in transplantation. These teams consist of social workers, psychologists, psychiatrists, nutritionists, physical therapists, financial counselors and transplant coordinators, in addition to the physicians and fellows involved in the program. The ability to perform routine laboratory examinations in addition to assays to measure levels of immunosuppressant medications, to perform microbiology cultures to rule out or identify infections and pathology services to interpret biopsy specimens to identify or rule out rejection, is mandatory. And of course, facilities and personnel must be available to perform the transplant procedures at any time, day or (usually) night. The nurses in the intensive care units and wards must develop the expertise to care for these patients. Many hospitals have developed separate transplant units to centralize and improve care for transplant recipients. In addition to academic medical centers, some larger private hospitals across the country, have developed transplantation programs. Overall, it is a huge investment in resources for hospitals to participate in solid organ transplantation.

Transplantation and the Non-Academic Community

In addition to the tremendous investment by physicians and hospitals to develop transplant programs, physicians all across the state and nation have had to learn about transplantation to care for the ever increasing proportion of their patients who need or have undergone transplant procedures. Like their counterparts in the academic medical centers, they have had to learn when to appropriately refer patients, and perhaps more importantly how to care for their patients' routine and potentially catastrophic post-transplant medical problems, including when to refer the patients back to the transplant center. Graduate medical education programs have helped disseminate this information, though perhaps the greatest source of information comes from the transplant centers, and more specifically the transplant coordinators. These highly trained and skilled individuals, usually nurses, nurse practitioners or physician assistants, are the patient's and their local physicians' lifeline for both routine care and emergency intervention. Our coordinators, as well as those at all centers, work very hard to be effective liaisons between the transplant center and the patients, their local physicians, hospitals and pharmacies. In reality, the entire process could not function without these dedicated individuals.

Conclusion

In the past two decades, solid organ transplantation has progressed from futuristic science fiction to life-saving procedures performed hundreds of times every day throughout the United States (over 23,000 transplants were performed in 2002). North Carolina has assumed its appropriate place in this scientific activity, providing its citizens and others from throughout the country, with these services. This activity has changed the practice and education of physicians, nurses and other medical personnel, and greatly impacted the hospital

services both in the community and the academic medical centers. Given the successes of transplantation, as well as new advances in immunosuppression, potential new sources of donors (non-heart beating human donors and genetically altered animals for xenotransplantation), and other new therapies for end-stage

disease (artificial livers and mechanical assist devices for heart failure), one can predict that 20 years from now, we will have even more sophisticated treatments that will have far reaching effects on medical practice and education, advances likely to eclipse even those of the past two decades.

Table 3.

Transplants by Donor Type and Center in NC

Transplants Performed: January 1, 1988 - October 31, 2003

	All Donor Types	Deceased Donor	Living Donor	
All North Carolina Centers	All Organs	7,911	6,248	1,663
	Kidney	4,414	2,818	1,596
	Liver	1,300	1,248	52
	Pancreas	59	59	0
	Kidney / Pancreas	329	329	0
	Heart	1,052	1,052	0
	Lung	719	704	15
	Heart / Lung	38	38	0
Wake Forest University Baptist Medical Center	All Organs	957	689	268
	Kidney	835	567	268
	Pancreas	12	12	0
	Kidney / Pancreas	26	26	0
	Heart	82	82	0
	Lung*	2	2	0
Carolinas Medical Center	All Organs	1,709	1,426	283
	Kidney	1,068	785	283
	Liver	262	262	0
	Pancreas	7	7	0
	Kidney / Pancreas	68	68	0
	Heart	304	304	0
Duke University Medical Center	All Organs	2,791	2,390	401
	Kidney	1,119	730	389
	Liver	506	500	6
	Pancreas	37	37	0
	Kidney / Pancreas	197	197	0
	Heart	437	437	0
	Lung	470	464	6
Durham VA Medical Center	All Organs	70	59	11
	Kidney	65	54	11
	Kidney / Pancreas	5	5	0
Pitt County Memorial Hospital	All Organs	617	286	331
	Kidney	596	265	331
	Pancreas	1	1	0
	Kidney / Pancreas	2	2	0
	Heart*	18	18	0
UNC Hospitals	All Organs	1,767	1,398	369
	Kidney	731	417	314
	Liver	532	486	46
	Pancreas	2	2	0
	Kidney / Pancreas	31	31	0
	Heart	211	211	0
	Lung	247	238	9
	Heart / Lung	13	13	0

Source: Based on OPTN data as of January 23, 2004 (www.optn.org). * No longer performing this procedure.