Successful Models of Interventional Nephrology at Academic Medical Centers

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The foundation of endovascular procedures by nephrologists was laid in the private practice arena. Because of political issues such as training, credentialing, space and equipment expenses, and co-management concerns surrounding the performance of dialysis-access procedures, the majority of these programs provided care in an outpatient vascular access center. On the basis of the improvement of patient care demonstrated by these centers, several nephrology programs at academic medical centers have also embraced this approach. In addition to providing interventional care on an outpatient basis, academic medical centers have taken a step further to expand collaboration with other specialties with similar expertise (such as with interventional radiologists and cardiologists) to enhance patient care and research. The enthusiastic initiative, cooperative, and mutually collaborative efforts used by academic medical centers have resulted in the successful establishment of interventional nephrology programs. This article describes various models of interventional nephrology programs at academic medical centers across the United States.


The steady increase in the incidence of chronic kidney disease (CKD) in the United States has led to increased demands for dialysis access-related procedures and imposed a tremendous burden on the health care system. While nephrologists’ surgery and radiology colleagues have made concerted efforts to deliver timely care, treatment delays persist (1–3). To optimize care, procedural aspects of nephrology have steadily evolved over the past decade. Gerald Beathard (4,5), in private practice, laid the foundation for endovascular procedures to be performed by nephrologists and initiated this specialty’s much-needed training component. The American Society of Diagnostic and Interventional Nephrology (ASDIN) was founded in 2000, and its published training guidelines generated a renewed interest among nephrologists not only to master procedural skills but also to participate actively in coordinating and becoming team leaders in dialysis-access care (6,7).

Early interventional nephrologists’ initiatives led to significant improvements in the fragmented and suboptimal procedural aspects of nephrology, with a steady growth of such programs at academic medical centers (AMCs), although well-developed systems for training, quality assurance, and certification currently remain in evolution (3). The first AMCs to initiate interventional nephrology services were established in the late 1990s and early 2000s and have provided excellent patient care (3,8).

The most common AMC-based programs can be broadly defined as: (1) hospital-based programs; (2) free-standing outpatient dialysis-access centers; (3) interventional nephrology programs collaborating with cardiac catheterization laboratories; and (4) interventional nephrology programs collaborating with interventional radiology. In this report, we describe programs successfully established in academic settings across the United States. It is anticipated that the description of these programs will encourage other AMCs to evaluate their resources and develop their own interventional nephrology services.

Model of a Hospital-based Program

Louisiana State University Health Sciences Center, Shreveport (LSUHSC-S)

The Interventional Nephrology Program of LSUHSC-S was established in 1995 under the direction of Jack Work, then Chief of Nephrology. Procedures were performed in a single suite next to the acute hemodialysis unit. LSUHSC-S was one of the first AMCs to establish a nephrologist-run facility with the sole
purpose of providing vascular and peritoneal access for dialysis patients. Other AMCs have since followed their lead and established hospital-based interventional nephrology programs, including St. Louis University, University of Louisville, University of Oklahoma, University of Kentucky, University of California, Davis, and University of Michigan.

**Staffing, Equipment, and Patient Care Services.** The current facility has two suites, each containing an operating table, two operating room lights, an ultrasound machine, and a C-arm. Additional rooms are available for vascular ultrasound studies, catheter removals, computerized data recording, and general storage. Its proximity to the acute hemodialysis unit is convenient for providing hemodialysis to patients before and after procedures. Some nurses are cross-trained in hemodialysis and can provide assistance in the acute hemodialysis unit.

Initially, the program at LSUHSC-S provided limited services, restricted to placing peritoneal dialysis catheters, cuffed tunneled hemodialysis catheters, and thrombolysis/angioplasty for clotted arteriovenous grafts. The program gradually expanded to include advanced procedures, such as stent placements and obliterating accessory veins of immature arteriovenous fistulas. The referral base is from diverse sources: 250 to 300 maintenance hemodialysis patients followed by faculty, private practice patients, hematology/oncology referrals for port catheter placements, and hematology/oncology, neurology, and medicine referrals for central venous catheters, trauma lines, and tunneled catheters for plasmapheresis and cytophresis.

**Fellow Training.** All nephrology fellows have the opportunity to train in interventional nephrology for 4 months during their general nephrology fellowship. Four fully trained faculty members perform all procedures and supervise the fellows.

**Models of Free-standing Outpatient Access Centers**

*Wake Forest University School of Medicine (WFUSM)*

WFUSM operates 14 outpatient dialysis facilities across northwestern North Carolina and is one of the nation’s largest university-run programs, managing over 1200 dialysis patients. Approximately 50% of the patients are managed by several nonacademic community nephrology groups. WFUSM’s off-campus vascular access center, Dialysis Access Group, was established in January 2007.

**Staffing, Equipment, and Patient-care Services.** Dialysis Access Group uses two ASDIN-certified interventional nephrologists and has two procedure rooms, a nine-station pre- and postprocedure recovery area, and required clean and dirty storage areas. Major equipment includes two C-arms, a portable ultrasound machine, two radiology procedure tables, cardiac monitors, a crash cart, infusion pumps, and bedside blood monitoring devices.

Referrals from various dialysis centers are on the basis of regular monitoring of the vascular access by trained dialysis personnel using Kidney/Dialysis Outcomes Quality Initiatives (K/DOQI) guidelines and a blood flow surveillance program. At present the center limits procedures to hemodialysis vascular access interventions and does not perform kidney biopsies or peritoneal dialysis catheter placements. Endovascular procedures include fistulograms, percutaneous balloon angioplasties, thrombectomies, and advanced procedures such as intravascular coil and stent insertions. Catheter-related procedures include tunneled and nontunneled catheter placements, exchanges, and fibrin sheath disruptions.

Most (62%) of the patients at WFUSM have arteriovenous fistulas (AVFs), and 15% have arteriovenous grafts as their vascular access. A cuffed tunneled catheter is the initial vascular access in 80% of the incident dialysis population, with 26% remaining catheter-dependent, similar to national data reported in the United States Renal Data System database. The center has successfully performed 2624 procedures since its inception, an average of 1.53 procedures per patient per year.

**Fellow Training.** The nephrology fellows of WFUSM are currently trained in interventional procedures. Additional resources are being organized to offer a third year of training for candidates interested in obtaining certification and pursuing interventional nephrology as a career. Didactic lectures on dialysis access have been incorporated into the regular fellowship syllabus as part of general nephrology training.

*University of Miami Miller School of Medicine*

**Staffing, Equipment, and Patient-care Services.** University of Miami Miller School of Medicine’s program began about a decade ago with an ultrasound program and peritoneal and tunneled catheter-related procedures. It has since expanded to offer a wide range of endovascular services, similar to those noted above, and currently performs 750 to 900 procedures per year. The program was one of the first AMCs to report its experience and has made major contributions to the literature. The center has two procedure rooms, a pre- and postprocedure recovery area, C-arms, a portable ultrasound machine, and a peritoneoscope. Two ASDIN-certified interventional nephrologists serve as team leaders. Renal fellows and the nephrology nursing staff form the backbone of the program.

**Fellow Training.** The program offers rotations to fellows to familiarize them with a variety of interventional nephrology procedures. Over 25 nephrologists have received endovascular training at this program.

*Emory University*

The renal ultrasonography program at Emory began in January 1994. Since then, over 5900 ultrasound studies have been performed, with approximately 100 currently performed each month (general study topics shown in Table 1).

The interventional nephrology program began in June 2001. Initially the program was hospital-based, located first in interventional radiology and then in a cardiac catheterization laboratory. The Dialysis Access Center of Atlanta, a freestanding center, opened in January 2003 as an extension of the Emory clinic.

**Staffing, Equipment, and Patient-care Services.** The center, staffed by three ASDIN-certified nephrologists, has two procedure rooms and a pre- and postprocedure recovery area and is equipped similarly to other freestanding centers. Since
opening in 2003, the center has performed over 10,800 procedures.

**Fellow Training.** Formal, comprehensive ultrasound training is incorporated into the nephrology fellowship training program. Fellows rotate through the ultrasound service for several months, performing all studies under faculty supervision and participating in the interpretation of data and generation of reports. The number and type of studies performed by each fellow are recorded, and fellows receive certificates documenting their training and experience in ultrasonography. Over 40 clinical fellows have received this training. Training for invasive procedures is offered both to practicing physicians and to fellows.

**Model of Collaboration with Cardiac Catheterization Laboratories**

*University of Wisconsin School of Medicine and Public Health (UWSMPH)*

UWSMPH has been involved in vascular access care through the University of Wisconsin Hospital cardiovascular medicine laboratory since January 2005. General nephrology operates three outpatient dialysis facilities, directly managing approximately 175 hemodialysis patients. Another 125 patients receive hemodialysis care locally in a private group. While care of these patients was initially provided by interventionalists at a non-university hospital, the academic program has now become a local referral resource for this practice. Additionally, over the past 5 years, the center has witnessed a marked growth in referrals from the region, representing a geographic radius of approximately 150 miles.

**Staffing, Equipment, and Patient-care Services.** The on-campus, in-hospital vascular access center uses two ASDIN-certified interventional nephrologists. The cardiovascular laboratory is a state-of-the-art facility that has five procedure rooms and a 14-station pre- and postprocedure recovery area. Major equipment includes five stationary C-arms, a portable ultrasound machine, multiple cardiac monitors, crash carts, infusion pumps, automated injectors, and bedside blood monitoring devices. In addition, the laboratory is equipped with several endovascular devices that are not typically associated with interventional nephrology but that have been used to perform various advanced techniques in patients with challenging accesses.

The center only performs hemodialysis vascular access-related procedures, not kidney biopsies or peritoneal dialysis catheter placements. The core endovascular procedures performed are similar to other academic interventional programs. This program has enjoyed yearly growth over its 5-year lifespan, with success and complication rates well within Kidney/Dialysis Outcomes Quality Initiatives guidelines.

**Fellow Training.** UWSMPH nephrology fellows before 2008 were trained in these procedures as part of their general nephrology training. Didactic lectures on dialysis access have been incorporated into the regular fellowship syllabus as part of general nephrology training. In 2008, a third year of advanced interventional training was added. To date, two fellows have completed this training.

**Models of Collaboration with Interventional Radiology**

*Ohio State University (OSU)*

The Interventional Nephrology program at OSU College of Medicine and Public Health was established in 2004 to provide vascular access care to hemodialysis patients. The center is located in one of the affiliated hospitals, utilizing their interventional radiology suites.

**Staffing, Equipment, and Patient-care Services.** Three interventionalists share the responsibility of performing procedures. There are two well-equipped suites primarily used by interventional nephrology but also by interventional radiology, interventional cardiology, vascular surgery, and pain medicine. The center has a seven-bed pre- and postoperative observation area.

The clinical nephrology program at OSU manages approximately 200 dialysis patients at eight centers. The dialysis access is routinely monitored at the dialysis centers with online access flow measurements. The total number of procedures performed is limited by the size of the dialysis population. However, because the service at the access center is expeditious, approximately one-third of the patients seen at the center are referred by competing nephrology groups in the community. Besides the core endovascular procedures, native and transplant renal biopsies are performed on a regular basis.

**Fellow Training.** OSU nephrology fellows are offered 3 months of rotation in the interventional suite each year to fulfill ASDIN certification requirements. Fellows uninterested in performing procedures are allowed to trade their elective rotations with those who are. Currently, due to the limited number of procedures performed, the training is not offered to nephrologists in practice.

*University of Alabama, Birmingham*

**Staffing, Equipment, and Patient-care Services.** The Division of Nephrology of the University of Alabama, Birmingham, provides care to approximately 500 hemodialysis and 100 peritoneal dialysis patients under the supervision of 12 nephrologists. In July 2004, the departments of medicine and radiology developed a combined interventional nephrology-radiology service. Two access coordinators schedule and maintain a prospective, computerized database of all vascular access procedures (9). The procedures offered include kidney biopsy under real-time ultrasonography, peritoneal catheter placement, venous mapping, and core endovascular procedures as per-

**Table 1. Ultrasound examination performed at Emory University**

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<th>Procedure Description</th>
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<tr>
<td>Diagnostic studies of native kidneys and allografts</td>
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<td>Screening of end-stage kidneys for carcinoma</td>
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<tr>
<td>Guidance for percutaneous renal biopsy</td>
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<tr>
<td>Diagnostic studies of urinary bladders and</td>
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<tr>
<td>measurement of post-void bladder volume</td>
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<td>Visualization of veins for central venous catheterization</td>
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formed at other centers. Approximately 1400 procedures are performed each year.

**Fellow Training.** Training is jointly supervised by interventional nephrology and radiology faculty members. A separate 1-year fellowship has been offered for the past 2 years. Additionally, fellows have the opportunity to use interventional nephrology as an elective rotation. To date, seven fellows have completed training to achieve certification from ASDIN.

**Massachusetts General Hospital, Harvard Medical School (MGH)**

MGH's program began in November 2004 in collaboration with the vascular interventional radiology division. Nephrologists at MGH originally had minimal input into dialysis vascular access. Discontent and discord were prevalent in nephrology, vascular interventional radiology, and transplant surgery. To improve the quality of care and create a mutually beneficial work environment, collaboration between nephrology and vascular interventional radiology was explored. The collaboration has resulted in a significant reduction in the number of late shift dialysis treatments and has improved utilization of nursing time and financial resources (S.W., unpublished data). Communication among nephrology and vascular interventional radiology staff, nurses, and technologists has also improved. The combined program, equipped with a dedicated procedure room and a full-time access coordinator, has seen a steady increase in referrals since 2005.

**Fellow Training.** MGH nephrology fellows are offered training as an elective rotation. Establishment of a formal training program jointly supervised by interventional nephrology and radiology faculty members is under consideration.

**Pros and Cons of Interventional Nephrology at AMCs**

Hospital-based programs offer several unique advantages, highlighted in Table 2. However, a major disadvantage of hospital-based programs is the lengthy process used by hospitals in the procurement of new equipment.

Free-standing outpatient clinics provide convenience, timeliness, and reduced anxiety for patients, who generally experience minimal disruption of their dialysis schedule and are content to avoid visiting major hospitals for procedures (10). Misher and Schon (11), who started a free-standing center in the private arena, have now established a close affiliation with the University of Arizona, successfully maintaining the mission of training fellows and providing ideal patient care. However, AMCs with dialysis populations of less than 300 to 400 may find it financially difficult to sustain a free-standing center. Furthermore, being an outpatient clinic, hospitalized patients need separate arrangements for dialysis vascular access procedures, and co-morbidities such as mechanical heart valve, known severe anaphylactic radiocontrast allergy, compromised pulmonary or hemodynamic status, and morbid obesity could be limiting factors in performing these procedures in outpatient settings.

Collaboration allows the addition of advanced procedures such as excimer laser, endovascular ultrasound, endoluminal atherectomy devices (12); (13); renal artery intervention (14); and tethered tunnel catheter removal using laser sheath (15). Collaboration creates a bond among services, leading to a healthy work environment. Regular multi-specialty dialysis vascular access conferences improve understanding of associated problems and overall quality of care. Treatment plans for patients with difficult vascular access can be effectively formulated and implemented as a team, avoiding delays and unnecessary multiple visits.

**Major Hurdles in Establishing AMC-based Programs**

There is a potential for political “turf” issues and/or disagreements over financial matters if there is a lack of strong support from the administration and leaders of various divisions (16). The training and credentialing of nephrologists remain major hurdles for AMC-based programs. Several AMC-based programs were established by nephrologists trained in the private sector. Privileges to perform procedures were on the basis of empirical observations until ASDIN published definitive guidelines and criteria. The privilege to perform advanced techniques (such as stent deployment and coil embolization) by nephrologists currently remains institution-dependent. An understanding between interventional radiology and nephrology at WFUSM to divide the patient workload on the basis of their hospitalization status has been beneficial in improving patient care. Existing centers have managed to circumvent these problems effectively, but nevertheless the hurdle remains; however, the authors believe that available resources can be pooled and an effective vascular access team can be created in most settings.

**Achievements of AMCs**

**Patient Care.** Successful AMC-based programs have seen improvement in the overall care of dialysis-access patients, with equal success for patients on peritoneal dialysis and those on hemodialysis. For example, peritoneal dialysis utilization improved by 32% at the University of Miami after the interventional nephrology program’s establishment (2). Peritoneal dialysis catheters placed by nephrologists have been reported to survive longer with lower incidence of leaks and peritonitis compared with surgical placements (17,18).

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**Table 2. Advantages of a hospital-based interventional nephrology program**

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<td>The interventional fellow can take care of all acute noncuffed central lines, leaving the consult fellow to devote all his/her time doing consults.</td>
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<td>Surgeons and code team are available for back-up in case there is a surgical or medical emergency in the interventional suite.</td>
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<tr>
<td>It is easy to collaborate and share resources with other interventional physicians in the hospital.</td>
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<tr>
<td>In-patients requiring vascular access procedures can be accommodated along with the out-patients.</td>
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Similarly, endovascular interventions for dialysis vascular access by nephrologists have resulted in a greater number of patients dialyzing with an AVF. This improvement can be attributed to the greater awareness of the entire dialysis team and active implementation of timely and coordinated care. As shown in Figures 1 and 2, the AVF rate steadily improved at two AMCs after they established interventional programs with active nephrologist participation.

Research. Vascular access research has been reported in the radiology, surgical, and nephrology literature. The effect of nephrologists’ active involvement in the care of dialysis vascular access is evident in studies published since the development of interventional nephrology. Kian and Asif (19) reported that nephrologists have contributed to 57% of the studies published in peer-reviewed journals over the past decade, either independently or in collaboration (Figure 3), a significant number of which were from established AMCs. Moreover, of the total 1747 studies they noted, almost 50% were published in nephrology journals with high impact factors (Figure 4); however, the majority were observational or review articles, with only 2.9% on basic science. Although AVF-related studies increased from eight in 1997 to 57 in 2009, there remains a paucity of basic science research and randomized controlled studies. Incorporation of dialysis-access teaching into general nephrology training and more centers for basic vascular biology research are needed.

Rationale for the Development of Interventional Nephrology Programs at AMCs

A decade ago, radiologists and surgeons were the primary vascular access care providers. However, their lack of key knowledge about dialysis, combined with minimal understanding of issues related to access complications and their effect on quality of life, often resulted in apathetic, suboptimal, fragmented, and delayed care and ultimately dissatisfied patients (20). A major obstacle in achieving efficient and comprehensive vascular access care for the CKD population is lack of a widespread mechanism of providing this care. The current paradigm of disorganized care between radiology and surgical services is clearly inefficient and insufficient in sustaining the rising demands of the CKD population and has resulted in increased complication-related health care expenditures. There are too few physicians in a single specialty to effectively manage the vascular problems of the ever-growing dialysis population.

A team approach is an effective, efficient way of providing comprehensive care for dialysis access. Nephrologists can be team leaders, coordinating care with other team members. A nephrologist’s background knowledge and understanding of dialysis patients’ needs can be combined with other team members’ surgical and procedural skills. Management of clinical problems related to cardiac, endocrine, and metabolic disorders, along with vascular access surveillance and educating dialysis personnel and patients, remain the primary responsibility of the nephrologist. Procedural skills make nephrologists excellent team leaders, and the interventional radiology community recognizes that radiologists need to understand better the needs of the dialysis patient (21,22). A multidisciplinary approach is more beneficial to the dialysis population (23).

A major obstacle in providing optimal vascular access care is a shortage of physicians with necessary procedural skills. National residency-matching program statistics show that almost 30% of training spots in interventional radiology programs have remained vacant every year since 2005 (http://www.nrmp.org/data/index.html). A collaborative effort is needed in
the academic environment for interested physicians to receive necessary background training for procedural skills needed to manage dialysis vascular access problems. Obstacles faced by AMCs in training and acquiring credentials can be avoided by mutual consensus rather than by each department trying to maintain control over the patient population.

The available resources in a hospital for providing care can be better utilized if there is a team approach, as is evident from the centers that have successfully created hospital-based programs. The onus is now on AMCs to establish well-designed programs equipped to provide adequate training, implement quality assurance, and standardize trainee certification. Currently available training is not ideal and needs better organization and structure. The growth of academic programs will improve both patient care and understanding of the vascular pathology of dialysis access (24–26). Optimal utilization of resources and its economic benefits even in smaller hospitals is well-recognized and is applicable to academic vascular access programs (27,28).

Acknowledgments
Amanda Goode, MA, Research Program Development Manager, Department of Internal Medicine, WFUSM, is acknowledged for invaluable editorial assistance with manuscript writing.

Disclosures
None.

References
7. American Society of Diagnostic and Interventional Ne-


