How to Successfully Train a Modern Nephrologist: Experience from US Fellowship Training Practice

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Abstract

Background: Graduate medical education varies in different countries. There is a general consensus in training methods, including residency and fellowship training systems. The graduate medical education system in western countries including the UK and the USA has been shown to be successful. The new graduate medical education training system in China was recently established and is still evolving and being implemented nationally. **Summary:** This paper reviews the history of nephrology training programs in the USA, the role of the Accreditation Council for Graduate Medical Education (ACGME) in establishing and enforcing guidelines and curriculum for specialty training programs, the fellowship application and Match system for the recruitment of prospective fellows, and the quality control of fellowship training programs through rigorous evaluation and In-Training examination. This review specifically discusses the nephrology subspecialty fellowship and ACGME-accredited training pro-

grams in nephrology. The authors also provide several critical suggestions on the newly established postgraduate medical education training system in China, particularly in nephrology, based on experiences from successful US nephrology fellowship practices. **Key Messages:** The ACGME-accredited nephrology fellowship program has been shown to be effective and successful, which could provide an insight into the newly established graduate medical education training system in China. The authors are optimistic that reforms in Chinese medical training systems will be successful in the near future.

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Introduction

Although graduate medical education varies in different countries, there is a general consensus in training methods. Despite differences in pre-medical school education, students graduating from medical school generally undergo residency training before becoming independent practicing physicians. Physicians who are interested in becoming specialists usually require additional training, and the duration varies depending on specialty

requirements. Before the Accreditation Council for Graduate Medical Education (ACGME) was founded in 1981, the Liaison Committee for Graduate Medical Education, which was established in 1972, oversaw the postgraduate education and training for all MD physicians and the majority of DO physicians in the USA [1]. The ACGME, a non-profit organization, is currently responsible for evaluating and accrediting graduate medical training programs (residency and fellowship) in the USA. Generally, surgery requires at least 5 years of residency training time, while medicine or pediatrics require 3 years. The time for fellowship training also varies in the USA. This review describes the US fellowship training program, particularly as it applies to nephrology fellowship programs under current ACGME requirements.

US Fellowship Programs

The American Board of Medical Specialties (ABMS) was established in 1933. It is a non-profit, physician-led organization that is responsible for certifying specialists in numerous specialties, as well as creating and enforcing the standards of those specialties. Nephrology, as a specialty, began in the 1950s. Nephrology fellowship training programs were quickly established in the late 1950s and early 1960s. As an example, the renal fellowship training program at Washington University School of Medicine began in 1961. At that time, post-residency paths and training durations varied from institution to institution, but generally took several years to complete. Subsequently, fellowship training programs required accreditation by the ACGME, and became organized based on the ACGME fellowship specialty requirements. Nephrology fellowship training time varies from 2 to 4 years, depending on the physician's chosen career path. Clinical nephrology only requires 2 years of nephrology fellowship training. Fellows who are interested in pursuing academic research careers require one to two additional years of research training, during which fellows are financially supported by NIH T32 fellowship programs or by their mentors' own research grants. Transplant nephrologists must complete 2 years of general nephrology training as well as 1 additional year of transplant nephrology training.

There are currently 149 adult nephrology fellowship training programs in the USA, of which 115 programs belong to academic institutions. There were 834 fellows in training in 2017, of which 385 were in their first year of training. In total, 484 fellows were in training as first

years in 2018 [1]. There were 51 pediatric nephrology fellowship programs in 2017, with a total of 101 pediatric nephrology fellows in training; 33 were first year fellows [1]. The majority of adult nephrology programs at academic institutions have 4–6 fellows each year.

ACGME-accredited training programs have been funded by the US federal government. Before Congress passed the Balanced Budget Act (BBA) in 1997 [2], the number of physicians training in residency and in fellowship programs had been increasing for many years. Since the BBA passed, the federal Medicare program, the single largest source of funding for graduate medical education, capped the number of residents and fellows in training. This measure limits the growth in the number of residents and fellows [2].

Despite Medicare freezing funding support for graduate medical education and capping it at 1996 levels, the number of ACGME-accredited nephrology fellowship programs increased from 127 to 135 from 1998 through 2005, while the number of fellows increased from 635 to 822 during the same time frame [3]. In 2018, the number of nephrology fellowship training programs had increased to 149, and the total number of fellows in training reached 964. In 2019, nephrology fellowship programs offered 464 first year fellowship training positions [4]. This growth in fellowship numbers reflects the use of alternative funding sources, likely from local institutional support.

Institutions that host nephrology fellowship training programs must be accredited by the ACGME. As a result, educational programs in nephrology must be at least 24 months in length. Nephrology fellowships function as an integral part of the ACGME-accredited training programs in internal medicine. Although training programs can have multiple participating sites, the ACGME requires one designated primary training site. Moreover, the ACGME requires one faculty member be the program director who is responsible for overseeing the entire training program and ensuring its compliance with all ACGME requirements. The program director must devote at least 50% of his/her professional time to managing the (administration time) fellowship training program. Besides the program director, the nephrology fellowship programs consist of a number of core faculty members as well as other clinical faculty members who teach fellows in both inpatient and outpatient environments. Core faculty members must devote a significant portion of their time to fellow education and/or administration, including evaluations, etc. Faculty members in fellowship training programs must hold current certification with the ne-

phrology board. Training programs must also have a program coordinator who runs the day-to-day operations of the program under the program director's leadership and serves as an important liaison among the director, the faculty, and the fellows. The ACGME requires that the program director dedicate an average of 20 h/week of his/her efforts to subspecialty programs, including teaching and administration time, with sufficient time devoted to the administration of the program. Each program must have a key clinical faculty (KCF) who on average dedicate 10 h/week throughout the year to the training program. For programs with more than five fellows, a ratio of KCF to fellows of at least 1:1.5 must be maintained.

Nephrology fellowship programs must develop a curriculum consistent with ACGME requirements and implement them through 2 years of training (see the ACGME website; ACGME.org). A nephrology core curriculum was also developed by the American Society of Nephrology (ASN) and its Training Program Director's Committee in 1997 [5]. The curriculum for nephrology fellowship programs must contain the following components: (a) a set of program aims including competency-based goals and objectives for each educational experience designed to promote progress on a trajectory to autonomous practice; (b) delineation of fellow responsibilities for patient care, progressive responsibility for patient management, and graded supervision; (c) structured educational activities beyond direct patient care, and (d) advancement of fellows' knowledge of ethical principles foundational to medical professionalism. The program must also integrate the ACGME competencies into the curriculum, which include the following: (i) professionalism; (ii) patient care and procedural skills; (iii) medical knowledge; (iv) practice-based learning and improvement; (v) interpersonal and communication skills; (vi) systems-based practice, and (vii) assessing progress in fellow training in different phases/levels by the teaching attending and reviewed by a clinical competence committee using the Milestone evaluation system.

Programs set training goals for fellows every 6 months and generally expect fellows to achieve these goals through structured didactic lectures and through direct patient care ranging from inpatient consults for general nephrology, critical care, renal transplant services, outpatient weekly clinics, ambulatory care, and various electives. Fellows rotate monthly or every 4 weeks per block at different training sites or services. Fellows rotate with 1–2 assigned attending nephrologists for each block. They provide patient care under the supervision of the attending physician, learn clinical nephrology, and practice re-

quired procedural skills, including providing different types of renal replacement therapy, dialysis catheter insertion, and renal biopsy, etc. Fellows receive hands-on clinical training on a one-on-one basis with the attending physician. The training team usually consists of 1 attending physician, 1 fellow, 1 resident, and sometimes 1 student. Fellows are also required to perform academic and scholarly research (3–6 months) during their fellowship training. Fellows interested in academic or research careers usually need an additional year of training devoting their efforts to research and to developing their projects for grant applications. The ACGME detailed curriculum can be found under program requirements for graduate medical education in nephrology at the ACGME website (ACGME.org).

The Application and the Match System for Applicants

Applications to Nephrology Fellowship Programs

Nephrology fellowship training candidates require completion of 3 years of an ACGME accredited internal medicine residency program. Prospective fellows can apply for fellowship positions during their PGY-3 residency year. Depending on their personal interests, applicants can also apply for fellowship training after they have completed their internal medicine residency or even a few years later. The fellowship application process has been undergoing dramatic changes since 2007. Before 2007, fellowship candidates applied directly to nephrology fellowship programs. Through preselection processes, eligible applicants were invited for interviews by the fellowship program. After the interview, fellowship applicants were either accepted for training positions or turned down through mutual selection. In 2005, applicants started using the web-based platform, Electronic Residency Application System (ERAS), to apply to residency and fellowship programs. The transition to ERAS was voluntary and the majority of nephrology programs chose to participate. The ERAS system standardized the application process and simplified the application-selection protocol, making it easier to review and evaluate applicants. ERAS allows applicants to apply to multiple programs through one single application and establishes a uniform timeline for the interview process that is applicable to all nephrology training program directors. The system was first used by nephrology fellowship applicants who began training on July 1, 2007. Training programs that participated in the Match system found that the ERAS system greatly aid-

ed the selection of excellent applicants. Participating in the Match system permits a fair selection process for both applicants and training programs.

The Match

The National Residency Matching Program (NRMP) is a private, not-for-profit corporation that was established in 1952 to provide a uniform date for appointment to positions in graduate medical education in the USA. The Specialties Matching Service (SMS) of the NRMP conducts matches for advanced residency or fellowship positions. The Medical Specialties Matching Program (MSMP) is also administered by NRMP. The NRMP requires that 75% of programs fill all of their positions through the Match as a prerequisite for specialty participation. Medical specialties have a long history of participating in the Match system. Cardiology, gastroenterology, pulmonary, critical care medicine, and infectious diseases joined the Match in 1986. Rheumatology joined in 2005 and hematology/oncology in 2006. In June of 2007, nephrology fellowship training program directors voted in favor of participating in the MSMP [6]. Nephrology and endocrinology joined the MSMP in 2009 [7].

The Match provides applicants and programs with the time and opportunity to make an informed decision on their Match choices. Programs that currently participate in the Match for the 2020 academic year (start date July 1, 2020) can download applications, beginning July 15. The interview season occurs from the middle of July to the end of October. Match Day is December 4. Rank-order lists can be submitted from October 2, 2019, until November 20, 2019. This timeline allows programs and applicants to have a longer interview season. Applicants can submit their application during their PGY 3 year so they have enough time and opportunity to complete electives, make career decisions, and establish personal interactions with attending physicians in their interested subspecialty to secure reference letters for their fellowship applications.

To participate in the Match, nephrology training programs need to register with the ERAS system. During the first year of the Nephrology Match in 2009, there were 139 total programs registered with ERAS, but ultimately only 121 programs participated in the Match. There were 578 applicants for 367 positions within these 121 programs [7]. In that year's Match, 121 programs offered 305 clinical track positions, and 95% were filled; 16 programs offered 42 research track positions, and 93% were filled (data are from http://www.nrmp.org/fellow/match_name/msmp.stats.html) [7].

To protect the integrity of the Nephrology Match and maximize the benefits for applicants and programs, the ASN, the sponsoring organization of the Nephrology Match, adopted an all-in policy in 2015, requiring all nephrology training programs accredited by the ACGME to participate in the Match and offer all training positions through the MSMP [8].

Quality Control of Nephrology Training Programs

The nephrology fellowship training curriculum was created as per ACGME requirements. Based on the curriculum each training program creates fellow rotation schedules for patient care, organizes a series of core lectures and conferences for nephrology core knowledge, ensures compliance with procedure skill requirements, and provides a research environment for fellows' scholarly activities. The program ensures the training quality for all fellows through the following measurements.

Evaluation

In 1999, the ACGME and ABMS established the six core competencies designed to shift emphasis from process-oriented to outcomes-based standards in physician education. The use of an outcomes-based evaluation system would enhance the feedback that fellows receive about their performances. The six competencies are requirements in both residency and fellowship programs. Since July 2006, a single evaluation method is no longer sufficient to assess the competence of a trainee. Programs must demonstrate at least two methods of evaluation for each of the competencies. The ACGME recommends developing a structured portfolio for each trainee that includes foundational evaluations, direct observations, practice and data-based learning, and multisource evaluations [9].

Fellow evaluations are provided in writing through a web-based format by his/her supervising faculty member after completing the monthly rotation. Evaluations are also verbally given by faculty members during the rotation or at the completion of the rotation. Fellow evaluations are based on the six competencies (patient care, medical knowledge, practice-based learning and improvement, interpersonal communication skills, professionalism, and systems-based practice).

The ACGME introduced the Next Accreditation System and started to implement it in July 2013 in order to improve future physician practice using the peer-review system, base training program accreditation decisions on

trainee educational outcomes, and reduce administrative burdens associated with the core competency system [10]. Specialty-specific milestones were incorporated into competency assessments to monitor the progress of trainees in achieving acceptable performances in the six competencies. The Clinical Competency Committee, composed of KCF members, reports on each trainee's progress in achieving the milestones semi-annually [11].

In-Training Examination in Nephrology

Besides performance-based evaluations, another important aspect of a fellow's evaluation is the In-Training Examination (ITE) in Nephrology. The Association of Specialty Professors (ASP) launched an initiative to have all fellowship programs implement formal ITEs no later than 2010, as was done for internal medicine and other residency programs. The ITE is jointly administered by the ASN and the National Board of Medical Examiners (NBME). The exam is intended to facilitate learning by identifying areas in nephrology in which fellows may have knowledge deficits.

The ASN ITE is an internet-based test developed in conjunction with the NBME. The ASN ITE closely mimics the American Board of Internal Medicine's initial certifying exam in nephrology. The results of the exam allow nephrology training program directors to compare fellows from their institution to other examinees. The program directors can identify problematic subject areas that need further attention on a general and individual basis. The ASN ITE was created by a subgroup of the ASN Training Program Directors Executive Committee and has been given annually since 2009. The ASN ITE usually takes place every April onsite at registered institutions. Scores are sent from the ASN to program directors only. Program directors then distribute scores to each fellow.

An ASN ITE score can be used to formally evaluate a trainee's knowledge and can serve as an independent predictor of performance on the ABIM board certification examination. The score can also be used by programs to identify deficiencies in training [12].

Subspecialization in Nephrology

Like other internal medicine specialties, nephrology is becoming more and more subspecialized, with additional training available for transplant and interventional nephrology. An additional year of training in transplant nephrology is available through programs that are accredited by the American Society of Transplantation and the ASN. There are 42 accredited renal transplant training programs currently in the USA. Additional training in

interventional nephrology is accredited by the American Society for Interventional and Diagnostic Nephrology (ASDIN).

The American Society of Diagnostic and Interventional Nephrology has defined the criteria for the certification of interventional nephrologists and the accreditation of programs in ultrasonography, insertion of peritoneal dialysis catheters, endovascular procedures on arteriovenous fistulas and grafts, and placement of chronic venous catheters for hemodialysis (<http://www.asdin.org/>). Transplant nephrology and diagnostic and interventional nephrology are not ACGME accredited or recognized as subspecialties by the ABIM.

In recent years, many exciting opportunities and new subspecialties have emerged within the field of nephrology. Among these, critical care nephrology has become an important specialty in both clinical and research settings. Several critical care nephrology programs have been created in recent years to provide clinical care, research, and educational programs to interested trainees [13]. These are not yet ACGME accredited or recognized as subspecialties by the ABIM.

Interest is also growing in the areas of oncology/nephrology and glomerulonephritis, with some programs offering advanced training in these areas. As knowledge and expertise are expanded in onconeurology, glomerular disease, and home dialysis, it is clear that there will be a need for additional training and further subspecialization in the near future.

The Impact on the Newly Established Nephrology Subspecialty Program in China

Postgraduate medical education in China has been dramatically changing recently. In the past, residency and fellowship trainings were institutionally based and not open to the public. Training was not uniform, and variation in training quality was the norm. Hospitals accepted medical students as residents after they graduated from medical school. The majority of these residents remained as attending physicians at their training hospitals upon completion of internal training in their specialties.

Medical students who enter the top tertiary hospitals affiliated with top ranking medical schools received high-quality, rigorous training in their residency programs, and specialty fellowship trainings reflect the quality and reputation of these affiliated hospitals. On the other hand, medical students who enter secondary hospitals or community hospitals receive less rigorous training and may

receive very little training. As a consequence, patients do not trust the physicians in these hospitals. They know that these doctors are less experienced and have less training, and as a result they are unwilling to see doctors in these hospitals. Patients with common illnesses or less critical disease prefer going to major tertiary hospitals with esteemed reputations rather than the local hospital. Major tertiary hospitals have been overwhelmed with the inflow of patients, which has caused a major problem in China's healthcare delivery system.

To overcome these problems, China's postgraduate medical education system must undergo fundamental changes to guarantee universal and equal quality training for all medical school graduates. China's first step should be changing residency and fellowship training systems from hospital-based, internal training, to training systems that are open to the public, i.e., where accredited hospitals are not only responsible for their own residency and fellowship training, but also for accepting trainees from other non-accredited hospitals, usually secondary hospitals or community hospitals.

In December 2013, China's Ministry of Health along with six other Ministries issued residency training guidelines and adopted a so-called "5 + 3 + X" model for postgraduate medical education, meaning 5 years of medical school education, 3 years of residency training, and X meaning the number of years of fellowship training, depending on the different subspecialties training requirements. Internal medicine and pediatrics subspecialties usually take 3 years of fellowship training, and surgery or other heavy procedure-based subspecialties fellowship usually take longer. The Ministry of Health authorized the Chinese Medical Doctor Association (CMDA) to be responsible for establishing standards for all medical specialty training and for implementing policies developed by the Ministry of Health. The CMDA is a private, not-for-profit physician organization that works with the Chinese government to implement postgraduate medical education guidelines within every province in the country. In 2014, the CMDA established 28 residency review committees to set up training standards and oversee the implementation of training programs in these specialties, which is similar to the structure of the ACGME's committees.

In June 2017, the CMDA established pilot fellowship training systems in cardiology, pulmonary and critical care medicine, and neurosurgery. Since then, many other specialty fellowship training programs have been established. Through enormous effort, the CMDA implemented large-scale, systematic changes in China's residency and fellowship training systems in 2014. The CMDA in-

corporated well-established practices from the UK and the US graduate medical education systems into China's own graduate medical education system and unique healthcare system. The following suggestions based on experiences from ACGME-accredited fellowship training programs would be helpful in assisting China in developing its fellowship training structures, particularly in nephrology.

1. To ensure fair, equal, and qualified training, top-ranking university hospitals have to keep at least 50% of their training positions open to the public or outside applicants. The application should be submitted through a web-based system. After an interview and mutual selection process, all training programs should announce their application decisions on the same date nationally.
2. The Chinese nephrology society needs to establish a standardized curriculum for all fellowship training programs nationwide.
3. Nephrology fellowship programs need to focus primarily on clinical nephrology training. This would include exposure to inpatient wards, outpatient clinics, renal replacement therapy, transplantation, and interventional nephrology, as well as training in procedural skills including dialysis catheter insertions and performance of kidney biopsies.
4. Fellows who are interested in pursuing academic careers or in becoming physician scientists need additional years of research training.
5. An annual national unified examination for fellows-in-training should be established to assess training quality based on fellowship training years and the progress of the fellows' knowledge in clinical nephrology.
6. The minimal number requirement for all procedures that fellows must master should be established and fellows should create online log records for CMDA validation if needed. Fellowship programs should be responsible for implementing this requirement and for assessing the proficiency of all procedural skills of the trainees.
7. Teaching teams with a ratio of 1 fellow to 1 attending physician should be established as the training model for each rotation block and focus on training fellows in clinical competence and independent clinical decision-making on diagnoses and therapeutic plans.
8. An outcomes-based evaluation system should be established by assessing the six competences and administering milestone evaluations. Evaluations should be done monthly by supervising attending physicians.

Conclusion

The national nephrology fellowship training system in China will be reformed and advanced in the near future by the CMDA. Pilot nephrology fellowship training systems have been established at provincial levels. For example, nephrology fellowship training programs have been implemented by the Shanghai Municipal Health Commission. However, standardizing nephrology fellowship training is challenging and no training system is perfect when it is first implemented. The CMDA, along with the Chinese Society of Nephrology and the Chinese Nephrologist Association, could defer to ACGME-accredited graduate medical programs in the USA, particularly in nephrology, in their policy discussions and decisions. Regardless, China's residency and fellowship training systems will evolve and improve over time and we are optimistic that reforms in Chinese medical training systems will be successful in the near future.

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All the authors declare no conflicts of interest.

Author Contributions

All authors contributed to the idea, conceptual advice, and framework of this manuscript. H.C. wrote the manuscript; Z.J., X.C., and J.L.B reviewed and revised the manuscript.

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