Developing a Research Skill Set

Y. Nancy You, MD, MHSc[1] Brian Bednarski, MD[1]

[1] Department of Surgical Oncology, University of Texas MD Anderson Cancer Center, Houston, Texas

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Address for correspondence Y. Nancy You, MD, MHSc, Department of Surgical Oncology, University of Texas MD Anderson Cancer Center, 1400 Pressler Street, Unit 1484, PO Box 301402, Houston, TX 77230 (e-mail: ynyou@mdanderson.org).

Abstract

The recent decades have witnessed a significant expansion in the diversity of career paths within academic surgery. Although the skills for providing exemplary surgical care and for maintaining a strong work ethic are the foundations of an academic surgeon, deliberate career planning and organized acquisition of research skills contribute to the success of an academic career. In this article, we identify a set of core academic skills and propose a framework for acquiring them. We also describe specific career paths within academic surgery and provide an overview of the opportunities for acquiring specific skill sets. The development of an academic career is challenging, and firm knowledge of the personal motivations will sustain and endure the time needed for acquiring the needed skills.

Keywords
- academic surgery
- research skills
- clinical trials
- health outcomes
- surgical education

CME Objectives: After reading this article, readers will (1) understand common challenges facing academic surgeons and key skills for success; (2) become familiar with stages of adult learning and apply this framework to learning academic skills.

"Academic medicine" has been defined by the capacity for a health care system to think, study, research, discover, evaluate, innovate, teach, learn, and improve.[1] To an individual, these are the hallmark activities engaged by an academic surgeon, who also provides exemplary clinical care to patients. The recent decades have witnessed a significant expansion in the diversity of the nonclinical activities of an academic surgeon. There is also great variation in the structure for allocating effort toward clinical versus nonclinical of activities. Although such variety and personalization represent one of the attractions toward an academic career, it also highlights the challenges of such a demanding career path. Indeed, a strong work ethic is the basic foundation of this career. Sir William Osler had said "I propose to tell you the secret of life as I have seen the game played and as I have tried to play it myself…–WORK, it's the open sesame to every portal, the great equalizer in the world, the true philosophers stone, which transmutes all the base metal of humanity into gold."[2] The added task of research training should not compromise the clinical training that enables provision of exemplary surgical care. Indeed, rigorous clinical training will necessarily develop and refine personal attributes of work ethic, meticulousness, attention to detail, and ethical conduct, all of which are also fundamental to a successful academic career.

In the past, development of an academic surgeon has largely relied on the individual. The lack of a deliberate and organized approach has been thought to be responsible for academic burnout.[3] Indeed, a stepwise progression of education remains the usual and most reliable means of becoming a productive investigator. In this article, we aim to provide an overview of a framework for learning core skills that are translatable to different pathways of academic surgery. We then describe specific career paths within academic surgery and highlight opportunities for acquiring specific skill sets.

Challenges and Rewards of an Academic Surgical Career in Colorectal Surgery

Over the recent decades, concern has been raised regarding a dwindling work force for academic medicine and several threats to such a career path have been recognized (►**Table 1**). The lack of time is perhaps the most commonly felt challenge among academic surgeons. The need to balance personal and professional responsibilities can indeed powerfully influence a career choice. With increasing value being placed on family and personal needs among a workforce who likely entered the medical field with the work-hour restrictions in place, less time with family and less personal leisure time have been cited as deterrents to

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Table 1 Challenges and core skills in academic surgery

Potential perceived deterrents or threats to academic career	Core skills to develop in response
1. Lack of time	1. Time management and organization
2. Lack of funding	2. Grant writing and budgeting
3. Lack of experience or infrastructure for interacting with larger society	3. Presentation, communication, negotiation, and networking
4. Lack of well-defined career trajectories, mentorship, and leadership	4. Mentoring and leadership skills
5. Lack of sustained set of personal motivations or convictions	5. Self-conviction and self-motivation skills

an academic career path.[4,5] Emergency surgery, nights on call, and hours worked were all independent predictors of burnout reported by academic physicians in a 2008 survey by the American College of Surgeons.[6] Another group of factors that threaten an academic pathway consists of financial pressures. Research funding is increasingly limited and competitive, while pressures from personal finances and education debt may be mounting. Thus, wage structures based purely on clinical activity may be perceived as a disincentive toward academic pursuits. Third, academic success increasingly requires navigation among not only research collaborators but also other stakeholders outside of the academic environment, including patient advocates, industry representatives, policy makers, and others.[7] Traditional medical training has ill-prepared the surgeon researcher for these interactions and may thus also discourage pursuit of these endeavors. Finally, with the recognition of the significant role played by department chairs, mentors, and role models in career choice and advancement,[8] formalized mentorship and career development programs are currently being established and implemented.

Because the development of an academic career can be challenging and even uncertain at times, it is important to establish clear personal motivations for pursuing an academic career. These serve as a firm foundation for sustaining and persevering through the challenges that arise over time. Many academic surgeons cite the opportunity for lifelong intellectual stimulation as a key motivator for their careers. The ability to identify new findings that directly or indirectly improve the care of current and future patients is highly valued. In addition, some enjoy the wide variety and autonomy in designing their career path and their daily schedules. The frequent opportunities to collaborate with colleagues in exchange of scientific ideas, and to travel and work with others nationally and internationally are also unique motivations toward an academic career. Indeed, since over one-third (37.7%) of the academic surgeons may experience burnout,[6] having well-grounded personal convictions for the choice of a career path may help prevent burnout and maintain career satisfaction.

A Core Skill Set for Academic Surgery

Because these challenges of academic surgery exist regardless of the specific career path, it is feasible to devote time in gaining strategies that will address these challenges during the early stages of career development. Five main areas of key skills to foster are summarized in ►**Table 1**:

1. Perhaps of the foremost importance is personal time spent in defining and reflecting on the goals and motivations toward an academic career as discussed above. Solidifying and renewing the *self-convictions are essential for continued self-motivation*. Indeed, recognition of personal priorities and values often represents a prerequisite for further career development.
2. *Time management and organization skills*: The need to balance multiple demands and manage the sense of overload challenges every busy academic surgeon. Although protected time for academic work from clinical demands is valuable, it can be difficult to obtain depending on the departmental infrastructure. Numerous time management and organization strategies are available. Investing the time to learn about, select, and then master specific strategies that work well for oneself can increase efficiency and productivity while reducing stress and wasted time.
3. *Grant writing and budgeting*: In the competitive funding environment, the basic writing and presentation skills must be refined to tell a compelling story succinctly. In addition, a feasible and detailed budget will lend further support to the practical fundability of the proposed scientific projects. Additional key elements including organizing components of the proposal, coordinating and assembling supporting documents, creating and adhering to a timeline, and attention to detail are also critical to the success of any funding application.
4. *Communication and interpersonal skills for presentation, publication, networking, and negotiations*: Academic physicians rarely work in isolation. Effectively communicating their work to those who are outside of the particular academic field of focus is required for successful navigation among the stakeholders, for collegial networking, and for effective career advancement through negotiations. Interpersonal skills must bridge across a wide spectrum of personalities ranging from patient advocates, referring physicians, institutional administrators, philanthropic donors, and/or other policy makers.
5. *Mentoring and leadership skills*: Mentors play critical roles in defining the choice and the trajectory of academic careers. Sometimes, a team of mentors is needed to address the needs at different stages of career and personal

development. Identification of good mentors starts with knowing one's own goals and then finding surgeons who are already thriving at doing what one wants to do.[9] Key characteristics to consider also include: (1) mentor's personal motivations and convictions for their career resonates with your own; (2) the mentor has a track record of mentoring other trainees; (3) the mentor is accessible in his/her appointment book and in his/her personality; and (4) the mentor expresses a genuine desire to see the mentee succeed. It is equally critical to realize that the mentee must play an active role in the mentoring relationship. Sincere investment into the relationship is necessary. A list of key actions of good mentee may include: (1) being proactive in seeking out meetings and learning opportunities; (2) being humble to constructive criticism; (3) being realistic about taking on tasks that one can finish; and (4) being thankful to the mentor.[9] At the same time, academic physicians are called to be mentors to their trainees and leaders to their supporting team.[10] Mentorship has traditionally been under-recognized and appropriate academic compensation is only starting to be considered for excellent mentors.[4] Effective coaching, mentoring, and leadership skills will help ensure the talents of team members are fully realized and channeled toward the key tasks and goals.

A General Framework for Acquiring Academic Skills for Adult Learners

A detailed guide about specifically acquiring each of the core skills is beyond the scope of this article; however, a general approach to skill development is presented herein.[11] As originally proposed by Fitts and Posner,[12] learning can be viewed as a three-phase process (►**Table 2**).

During the initial *cognitive stage*, the learners gather information from different sources to find out why, what, and how about the tasks that need to be performed to acquire a particular skill. Translated into learning academic skills, learners should seek out and pay close attention to resources for the specific skills such as time management, organization, grant writing, negotiation, and others. Several broad categories of didactic resources are available:

Formal training courses or didactic seminars are often offered through professional societies such as the American Medical Association, American College of Surgeons, Association for Academic Surgeons, and others. They may be conducted in conjunction with or within the program of the annual meetings of these societies; detailed information can usually be obtained at society Web sites. Since some of these courses are repeated annually or biannually, one can often find past attendees for additional information and feedback. Grant-writing courses and mock study sections are available through the National Institute of Health (NIH), as well as the junior faculty seminars from American Association of Cancer Research, American Society of Clinical Oncology, and other societies. Individual academic institutions may also offer seminar series for junior faculty development and/or topic-specific seminars. Many of these courses have been adapted specifically for health care professional and may even have speakers who are academic surgeons themselves thereby providing highly relevant information.

One hallmark of adult learning is self-directed learning outside of the lecture hall. Indeed, because many of these skills translate across multiple professional disciplines beyond medicine, there are numerous *printed or internet material available for self-study*. For example, controlling time, managing emails, handling interruptions, assembling a support team, and negotiating career advances are topics that are so vital for success in the business world that they have been topics of many books and articles.

Another category of recourse about various skills is represented by the *collective experience of other academicians*. Just as different surgeons may conduct the same procedure differently and surgical trainees learn by observing and absorbing these different surgical techniques and approaches, the many academic surgeons will differ in their methods for time management, for personal and work life balance, and for team leadership. Whenever one has an opportunity to interact with seasoned academicians, making a conscious effort to either directly observe or specifically inquire about the techniques that have proven to work well for the particular person represent a highly efficient method of cognitive skill learning.

Table 2 The three-stage model for skills learning as proposed by Fitts and Posner

	Goal of the learning stage	Key characteristics of the learning stage	Potential activities as applied to learning academic skills
1. Cognitive stage	Acquire the knowledge of what, how, and when to do the different tasks to achieve the goal of the skill	High degree of cognitive activity, including listening to instructions and receiving feedback about errors	Formal didactic courses, seminar; reading books and articles; informal advice from peers, mentors, and other researchers
2. Associative stage	Practice and performance improvement	Consciously translates cognitive knowledge into competence	Self-directed practice; conscious trial-and-error; self and peer review for refinement and improvement
3. Autonomous stage	Skill has become "second nature"	High level of proficiency, consistency, and confidence	Mastery of the skills as a part of routine

The second learning phase, *the associative phase*, is where the learner converts the theoretical and learned knowledge into a personal repertoire of skills through experimentation and practice. In the setting of developing academic skills, this phase is typically self-directed. While some skills (e.g., time management) can be practiced easily on a daily basis, others may need to wait for special circumstances (e.g., negotiating a career move). During this phase, a large amount of conscious effort is spent in performing the tasks and skills. When multiple techniques are available, there may be a time for trial-and-error until those that suite oneself the best are identified. In addition, time for self-reflection and opportunities for others to provide feedback are two critical activities during this phase of learning. These lead to adjustments toward improved consistency and efficiency. Indeed, grant writing is an example of a skill set that lends itself well to peer review and mentor critique; additionally, some of the training seminars will include role playing with peers and/or group discussion activities for skills such as networking or negotiation.

The final phase of learning, usually reached after extensive practice, is *the autonomous phase*. This is hallmarked by full incorporation of learned skills into a part of oneself and one's routine, such that the skills are automatically executed. The skills are said to have become second nature to the learner. One challenge during this stage may be execution of learned skills during stress, or times of multiple demands.

In summary, we have offered a general framework for learning (►**Table 2**) along with a list of core skills (►**Table 1**) important for combating the challenges posed by an academic career. Adult learners are known to be self-directed, autonomous, goal oriented, and driven by relevancy. Thus, we again emphasize the importance of having a firm set of overarching personal motivations for career development along with skill-oriented goals and tasks.

Diverse Career Paths in Academic Surgery Today

Classically, an academic surgeon is a surgical investigator who cared for patients in the hospital, taught surgical trainees, and conducted experiments in the laboratory. Over the past few decades, the types of career paths in academic surgery have vastly diversified to include not only laboratory-based research, but also patient-oriented research in clinical trials, in epidemiologic and outcomes research, as well as other careers focusing on health education, health policy, and health administration. For surgical trainees, this diversity can be overwhelming, and choosing a particular career trajectory can be difficult and even stressful. However, the core academic skills (►**Table 1**) are translatable to whichever specific pathway is chosen. The training pathways and infrastructures for academic surgeons are being increasingly defined. Three major forms of adult learning are often integrated: degree-credit programs, organized instruction, and self-directed/hands-on learning (►**Table 3**).

The potential role for degree-credit learning in academic surgery is variable and is in part related to the individual's chosen academic path, the needs of the academic institution, and the additional time required to complete the training. The optimal time period to enter such a program is highly variable and points of entry range from dual degree programs concurrent with MD training to long-distance online programs concurrent with a full-time faculty position (►**Table 3**). Multiyear training programs leading toward master's degrees in clinical research, in public health, or in business administration have increased in popularity because some are offered through special long-distance or seasonal programs that enable physicians to complete course credits while maintaining a clinical practice. The completion of formal doctoral training in basic science (PhD) has remained relatively uncommon. This is likely secondary to the greater requirements for doctoral training, which typically includes formal graduate coursework and a formal basic science research experience that may range from 3 to 5 years to complete.

The "hands-on" experience can be viewed as a "wet-lab" experience where one gains a real-time exposure into a potential future career. Such an experience need not occur in a traditional laboratory. For example, the National Cancer Institute offers research fellowship positions for patient-oriented research and clinical trials; the American College of Surgeons and several large academic institutions offer specialized clinical research fellowships; and finally unique programs can be created on an individual basis. Immersion

Table 3 Potential pathways and infrastructure for developing an academic program

	Degree-credit programs	Organized instruction	Self-directed/hands-on learning
Medical school/interval years	Integrated/dual degree programs	Deferred medical school admission; summer/research internships or externships	Research projects
Residency and/or fellowship/ Interval years	Postgraduate degree programs	T32 training grants; institutional training grants; clinical/basic science research fellowships	Inside or outside of the institution; national programs
Junior academic position	Postgraduate degree programs; online/long-distance learning degree programs	Career development awards National Institute of Health K-series; professional societies; institutional training grants	Mentored academic program

into the "wet-lab" research experience is critical not only for the hands-on research but also for interactions with experts in the field, for reading and publishing on defined subjects, and for the opportunities to present and attend key meetings of the associated professional societies.

Finally, the infrastructure for dedicated time away may include deferred time for degree-credit study; institutional sponsored research fellowships; professional society sponsored career development awards; and finally NIH T32 training fellowships or K-series career development awards. The latter grant-related awards provide salary support thereby allowing for formal protected time away from clinical duties.

Below we discuss three of the most common pathways for academic career in surgery and illustrate how these components of learning can be integrated.

Patient-Oriented Research

Clinical and patient-oriented research is becoming perhaps the most common of the pathways among academic surgeons. Patient-oriented research can represent a natural extension of one's clinical practice, thereby facilitating the integration of clinical and research duties. Core areas of patient-oriented research include: (1) health outcomes research, (2) health services/quality improvement research, and (3) clinical trials research. *Health outcomes research* is a highly diverse field. Many of the questions examine epidemiologic or practice trends across time, patient groups, and locations; clinical outcomes along with practice, treatment, and other factors that impact such outcomes; or patient-reported outcomes such as patient preferences, health utilities, functional outcomes, and quality of life (QOL). *Health services/quality improvement research* is a multidisciplinary field that focuses the structure, process, and delivery of health care services on patient groups and on society, by examining the utilization, costs, quality, accessibility, delivery, organization, and outcomes of health care services.[13] *Clinical trials* represent a type of prospective human subject research conducted with a predefined protocol that is designed to answer specific questions about novel treatment interventions, with the goal of testing safety and/or efficacy. These trials can be conducted within an institution or can be conducted across institutions within the national cooperative groups' infrastructure. For surgeons in particular, the American College of Surgeons Oncology Group (ACOSOG) was a member of the NIH cooperative group trials program that was dedicated to studying surgically relevant treatments of solid tumors.[14] Today, ACOSOG has become the American College of Surgeon Clinical Research Program and has merged with two other cooperative groups the North Central Clinical Trials Group and the Cancer and Leukemia Group B into ALLIANCE for clinical trials in oncology, and many surgeons continue to play active and leadership roles in clinical trials research.[15]

The process of clinical and patient-oriented research is not different from that in any research field. In general, one first gathers an adequate amount of general information about a research field to understand the gaps in current knowledge and identify key questions to be answered to advance the particular field. This clinically interesting inquiry must then be formulated into an answerable research question with a testable hypothesis through a process of refinement. Input from experts and experienced researchers in the field are often critical at this step. Third, a stepwise plan is devised toward testing the hypothesis. This may include asking a series of successive questions, designing a set of small studies, and deciding the methods and resources that will be needed to answer these questions. Finally, one sets out to conduct the research and this process will involve troubleshooting, interpreting data, linking findings into the larger rubric of the research question, and then identifying the next frontier of questions. These steps are often most efficiently acquired by immersion into a "wet-lab" type experience and hands-on conduct of research projects with experienced researchers.

There are some specific methodologies used in clinical and patient-oriented research. Degree-credit learning or topic-specific seminars/courses represent formal ways of learning about these methods. For example, the American College of Surgeons and the Association of Academic Surgeons sponsor intensive courses in outcomes research and in clinical trials methodology. For health outcomes research, one common method is statistical analysis of large epidemiologic, administrative, or clinical databases. These require practical application of statistical knowledge and commonly used databases include the Surveillance, Epidemiology and End Result program (SEER), the SEER-Medicare, the National Cancer Database, the National Surgical Quality Improvement Program, the National Inpatient Sample, and many others. These databases differ in the types of patients included, the data points collected, the degree of granularity of data, their method for data coding, as well as the process of data collection, reporting, and quality assurance. Understanding the specific data coding dictionaries, including the International Classification of Disease codes or the Current Procedural Terminology codes, can greatly facilitate data searches. In addition, the databases differ in accessibility. The process of obtaining Data User Agreement and Institutional Review Board approval should take place with each specific database. Indeed, the data managers of each database represent a helpful information source. Finally, it is critical to understand the limitations of each database, so the researcher can answer the question "can this database really help answer this question?" and perhaps embark on a process of refining the data source and/or the study question. Another common method of outcomes research involves patient surveys to collect patient-reported data such as preferences, health utilities/trade-offs, and QOL. The methodologies of questionnaire design and validation can be learned. More practically, a variety of validated measurement tools already exist for measuring both general health-related well-being as well as disease-specific issues. Reading previous literature where these tools had been used and working with researchers in the field can help one determine which instruments would be optimal for the patient population and the research question being investigated. Additional more specific methodologies include meta-analysis of the literature, and decision modeling including cost analysis, cost-effective analysis, and decision analysis. It is often helpful for a clinical researcher to collaborate with a "methodologist," one who fully

understands the utility and limitations and can practically operate the software that is associated with these methods. The collaboration should be established as early as possible in the design of the research study. In such process of collaboration, the clinician often learns a tremendous amount and thus becomes a more experienced researcher.

Basic Science and Laboratory-Based Research

For surgeons seeking an academic career that is grounded in basic science research, a strong foundation in scientific method and bench research techniques is critical. Traditionally, these skill sets have been founded in research experiences conducted throughout undergraduate studies, medical school, and/or during residency/fellowship. Although committing to formal doctoral and postdoctoral training requires careful consideration due to the significant time commitment, the increasingly complex strategies required for research and the increasingly competitive funding environment may motivate the aspiring academic surgeon.

The most traditional pathway to obtain a PhD is the combined MD/PhD medical school program. The perceived benefit is that the scientific foundation is created early and extended interruption of the clinical surgical training can be avoided. However, the decision for the dual degree program has to be made early and, not infrequently, surgical trainees' interest in basic science research is cultivated later in residency during elective research years. As a result, alternative pathways have also been used including completing the doctorate degree during the research years in the midst of surgical residency or even completing the degree requirements as faculty.

However, it is important to realize that a successful basic science research program can be established without completing a formal PhD program. Experience can be gained through hands-on training during wet-laboratory research experiences during residency and fellowship. To provide the best chance for success, it is important to seek out excellent basic science (PhD) and surgeon scientist (MD) mentors. Moreover, find an environment where there are collaborative doctoral students or postdoctoral fellows to create a fertile environment to nurture scientific curiosity and further knowledge and skills.

One issue to remember is with or without pursuing a doctoral degree, basic science experiences can leave large gaps of time between the wet laboratory and the clinical arena. One strategy is to pursue fellowship training at institutions that have research tracks that will provide the resources necessary to further the laboratory skill set needed to succeed at the junior faculty level, including successful surgical scientists on the faculty, dedicated research time away from clinical duties, and funding opportunities such as T32 grants. Such time during fellowship training permits the development of projects, ideas, and skills that will enable an easier transition to an academic surgical scientist position.

Education

As surgical education has evolved, the need for surgeons interested in academic careers focused on the successful training of surgical residents has grown. The changes to the way surgery and medicine is practiced have resulted in increased scrutiny and increased challenges to be able to demonstrate competence in the many facets of complex patient care. The field of surgical education provides three pathways for surgeons to pursue an academic career. The first is through a leadership pathway that focuses on developing the tools to help run a surgical education program; the second is centered on educational research; while the third is the most common in that surgeons can participate in resident/medical student education through giving lectures, instructing anatomy courses, and participating in surgical education on the wards and in the operating room.

As the importance and the difficulties of surgical education are recognized, formal master's degree programs in education concentrating on health care professional's education have increased. These postgraduate degree programs can foster a career path toward a leadership position in surgical education, such as residency or fellowship program director (including curriculum development, mentoring, leadership, etc.) at the institutional or national levels. Skills acquired in these degree programs can foster meaningful educational research that can yield evidence-based methods for surgeon education (research methodology, survey research, statistics, etc.). Additional areas of research include techniques of teaching, methods of learning, and fundamentals of how to provide an atmosphere that promotes learning and the attainment of competence. Besides formal degree-credit programs, several surgical societies conduct seminars focusing on education. For instance, the American College of Surgeons offers an intensive 1-week course entitled "Surgeons as Educators"; the Association for Surgical Education sponsors the Surgical Education Research Fellowship that provides support and mentorship for a research project in surgical education. Understanding the increased need to provide support for surgeons participating in resident and medical student education has generated an increasing number of resources to help improve the educational experience for both faculty and residents/students.

Conclusion

Academic surgery is a uniquely challenging but rewarding career. With increasing variety of the successful career paths, there has been increasing support for acquisition of skills needed for success. The development of firm personal motivations and convictions for pursuing such a career is fundamental for skill development. Development of both core and specific skills may integrate formal didactic learning with hands-on "wet-lab" experiences. Ultimately, the deliberate career planning along with strong work ethic and acquired skills will help ensure the continued viability of academic surgeons.

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