Cardiothoracic surgery residency training: Past, present, and future

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Background: A dramatic transformation of cardiothoracic surgical education has evolved over the past few decades.

Methods: We begin by presenting recognized catalysts of this change, organized by whom they primarily affect: the trainees, the trainers, and the profession as a whole. Our trainees' prior training is different, and their current demographics and priorities have changed. There is less incentive to teach, with time-honored traditions of education inadequate to meet the needs of trainees. Concurrently, our profession has to adjust to new regulations, increasing financial constraints, and an expanding body of knowledge and technology. To address these issues requires developing new models of education and assessment that can thrive in today's environment. We discuss efforts in the United States and abroad, including new training paradigms ranging from restructuring existing models to novel approaches (eg, competency-based training). Training tools are being developed, such as online instruction, simulation-based learning, and regular student-centered assessments. Finally, models that recognize and reward teaching as a scholarly activity are being implemented.

Conclusions: Like the radical advances we have witnessed in surgical therapy, surgical education requires creative and perhaps disruptive changes if we are to continue to produce well-trained additions to our professional ranks. (J Thorac Cardiovasc Surg 2013;146:759-67)

Education of cardiothoracic (CT) surgical specialists is facing a number of unique challenges. Many threats internal to our profession have sprung from changes in practice, trainees, and indeed educators themselves. External forces intensify the impact of internal challenges and increase the urgency of finding a solution. Recognizing the myriad of threats, in this review, we describe the most consequential and pervasive ones and group them into a basic framework organized by whom they primarily affect. Finally, we describe the current projects through a multitude of organizations that are addressing many of these very threats.

ISSUES AFFECTING CT SURGICAL TRAINING

Considering the variety of challenges, there is a need to develop an organizational framework. Inasmuch as many challenges are deeply and broadly embedded in our educational system, no single organizational classification will be neat and orderly. Therefore, we selected one that

is intuitive and based on the group the challenge primarily affects, recognizing that at some level all challenges impact our profession. Hence, 3 broad groups emerge: trainee, trainer, and profession as a whole. The last tend to include external threats that affect both the trainer and trainee equally. Such a framework may help guide the development of a broad set of solutions.

Issues Affecting the Trainee

Prior training. Perhaps one of the most obvious challenges has been the transformation of general surgical training over the past 20 years as outlined by Lewis and Klingensmith.¹ Surgical treatment of benign peptic ulcer disease, biliary stone disease, abdominal vascular disease, and trauma, once considered the clinical staples of the general surgical trainee, have been affected by advances in diagnostic imaging, medical management, or technology. Surgery for peptic ulcer disease and its complications have almost been eliminated by the use of H2 blockade, proton pump inhibitors, and treatment of *Helicobacter pylori*. Biliary stone disease is now commonly approached by use of a flexible endoscope and endoscopic retrograde cholangiopancreatography. Eighty-five percent of abdominal aneurysmal and aortoiliac occlusive disease is now treated with endovascular techniques, essentially eliminating an open surgical approach. Finally, imaging technologies, such as computerized axial tomography or magnetic resonance imaging, have reduced the need for exploratory laparotomy in trauma patients. The overall reduction in case volume in general surgical training has been dramatic.² In addition, general surgical training has also

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Disclosures: Authors have nothing to disclose with regard to commercial support. Received for publication June 11, 2013; accepted for publication June 14, 2013; available ahead of print July 18, 2013.

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<http://dx.doi.org/10.1016/j.jtcvs.2013.06.004>

Abbreviations and Acronyms

ACGME	= Accreditation Council for Graduate Medical Education
CT	= cardiothoracic
JCTSE	= Joint Council on Thoracic Surgery Education

seen a dramatic transition from open surgical to minimally invasive approaches. The first consequence of such a transition is the erosion of open surgical skills that are highly valued by CT surgeons. A second impact is the formation of fellowships not accredited by the Accreditation Council for Graduate Medical Education (ACGME), in part supported by industry, that are providing training for these new techniques. These fellowships result in a migration of cases previously done by general surgical residents into the hands of postresidency fellows; this process in turn leads to a perception by general surgical residents that additional postresidency training is necessary for transition to independent practice. In a survey of 4402 surgical residents in the United States, Yeo and associates³ found that more than 50% believed that postresidency training was necessary to become successful and competitive and have a better lifestyle. Currently, more than 80% of general surgical graduates secure fellowship training.

In reviewing the number of total and chief resident cases, Eckert and associates² reported a decline from an average of 966 to 914 total cases in a 5-year general surgical residency over a 9-year period (1999-2008). Bell and associates⁴ reviewed 121 basic surgical procedures that 254 program directors considered essential for a graduating general surgery resident to be competent to perform independently. They noted: "Graduating 2005 residents (n = 1022) performed only 18 of the 121 procedures an average of more than 10 times during residency ... for 63 of the 121 procedures, the mode experience was 0." Not only have the numbers of procedures declined but their complexity as well; cases previously considered "minor" now represent more than 70% of reported general surgical cases.⁵

Recognizing the natural evolution in disease management, other factors have affected surgical training. The introduction of the 80-hour work week in 2003 has yielded expected and unexpected consequences. Surgical residents before 2003 averaged 90 to 100 hours per week in the hospital. The potential outcome that limiting duty hours would decrease operative experience has been observed in both general surgery and CT surgery.^{6,7} To provide coverage to various services, a greater reliance on resident "float" call has led to a decreased continuity of care and less autonomy, which has affected the trainee's opportunity to develop clinical decision making.^{8,9} Although other factors may decrease trainee autonomy

(related to issues affecting the trainer and our profession as a whole), less access to patients outside the operating room and diminished continuity of care with frequent "sign-offs" are important contributors. In addition, the cost of limited work hours virtually eliminated specific rotations (including CT surgery), didactic teaching conferences, and bedside teaching opportunities.¹⁰ The shift-work paradigm has necessitated the use of constant interresident handoffs, which has compromised patient safety. Another unexpected consequence is the diminution of the general surgical trainees' exposure to surgical subspecialties. Limited duty hours coupled with coverage constraints has led to a concentration of trainees on core general surgical rotations with fewer opportunities to rotate on CT surgery. In a recent survey of general surgical trainees, nearly 54% rotated for less than 1 month or never rotated on a CT surgical service.¹¹ Not only does less exposure affect the trainee's decision to pursue CT surgical training but it also affects their core knowledge of thoracic anatomy and basic thoracic surgical procedures. Interestingly, whereas negative effects of duty hour limitations have been documented, positive outcomes (more rest and greater time for reading) have been inconsistent.

Trainee demographics. An important change has been the steady increase in foreign medical graduates and women entering the field of CT surgery. Both shifts have increased the overall pool of qualified applicants and the ability to select the best candidates. In addition, the impact of generational differences, ideologies, and experiences is becoming better appreciated. Before World War II, the "traditionalist" generation from 1925 to 1945 is influenced by the Great Depression, understands delayed gratification, and values family, community, and country. The "baby boomer" generation from 1946 to approximately 1964 is influenced by civil rights and the Vietnam War, is more competitive, and rejects authority. They believe that work trumps family and value success. "Generation X" spans the years from 1965 to 1980. Many were born to single parents and influenced by AIDS, cell phones, and cable television. They are independent, skeptical, and lifestyle-conscious, and they value time. Most recently, since 1980, the "millennium" generation is influenced by doting parents, 9/11, and the World Wide Web. They work best in teams, are technologically savvy, and value individuality.¹² With our profession having an average age of 55 years and incoming trainees averaging 26 to 34 years in age, there are perceived tensions among generational ideologies. Some middle ground between technologically savvy, lifestyle-conscious trainees and their competitive workaholic trainers will need to be reached.

Issues Affecting the Trainer

Decreased incentive to teach. One of the most ubiquitous changes that have affected surgical education over the past

100 years has been the gradual shift in the primary focus of academic surgeons. The history of this transition is described in detail in “Time to Heal: American Medical Education from the Turn of the Century to the Era of Managed Care” by Kenneth Ludmerer.¹³ Ludmerer identifies 3 historical periods defined by clear shifts in the focus of academic medical centers. The first period began in 1910 with the publication of Abraham Flexner’s landmark exposé titled “Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching.”¹⁴ Flexner¹⁴ derided the proprietary trade school approach to medical education that was prevalent at the turn of the century and recommended the closure of such schools. What few remained were institutions that focused on education as a priority. Clinical activity was valued only for its contribution to the educational mission of the institution. Research, while becoming of more importance, was still secondary to the primary mission of education. Johns Hopkins Hospital, an archetype of this educationally focused academic center, developed the model of surgical training that was adapted by John Alexander for the training of thoracic surgeons. The first professional society in thoracic surgery, The American Association for Thoracic Surgery, was founded in 1917 based on “Promoting Scholarship and Education in Thoracic and Cardiovascular Surgery.”

For the next 35 years this model prevailed until the conclusion of World War II. The National Institutes of Health, founded in 1930, began to witness explosive growth in an era of vaccines, antimicrobial drugs, and advances in surgical techniques. The public, in concert with the government, recognized the value of these advances, and resources poured into academic centers to spur their development. Slowly but inexorably the primary mission of academic medical centers shifted toward research; the emphasis on education thus diminished.

This era also saw the rise of CT surgery. Technologic advances led to the primacy of CT surgery in the treatment of thoracic malignancies and ischemic and valvular heart disease. Graduate medical education in thoracic surgery grew in the United States, reaching a maximum of 93 residency programs, training approximately 350 residents per year.

Similar to the second era, the third era began slowly; a turning point likely occurred in 1965 with the introduction of the Medicare and Medicaid Acts. The steady rise in health care costs coupled with periodic economic slow-downs led to decreased hospital revenue both from patient care and from research. The academic medical centers, bloated from decades of financial excess, found themselves searching for new revenue sources to support their expenses. They began to leverage their position as centers of excellence and compete aggressively to increase patient volume and clinical revenue. The primary mission now

focused on revenue generation with clinical revenue the driving force; research in that it could generate revenue remained a close second. Finally, resident education, perceived as an unfunded mandate, was relegated to a distant third.

It is in this last current era that our education system is mired. Academic institutions have used incentives linked to clinical and research revenue generation to focus their faculty efforts. Others have used systems to quantitate educational activity in the hope to provide an equivalent system for faculty, in the form of teaching credits or educational value units. However, few if any incentives exist for educational endeavors. As Jerome Kassirer, MD,¹⁵ summarized in his review of “Time to Heal,” this most recent historical time frame is “a later period of the erosion of professional values and a deterioration in the environment of medical education.” Although it is doubtful that financial support of education will increase, there is the possibility of other types of incentives.

Coupled with the lack of financial incentives to teach is a disincentive to teach resulting from ever increasing scrutiny on clinical outcomes. Pay for performance and other outcome-based reimbursement plans are increasingly common. Clearly, we agree with efforts to address the widespread errors that plague our health care system,¹⁶ but the unintended consequences of such efforts has been to further distance trainees from patient care. Many faculties interpret the need to focus on patient outcomes as an implicit deterrent to allowing trainees to have any autonomy in the care of patients.

Educational training. Not widely recognized is that academic faculty may have limited training in educating residents and medical students. A common misconception is that expertise in the performance of a skill confers excellence in teaching that skill to others. In addition, the capacity to teach is not a singular skill but includes a variety of techniques and behaviors, and it is the rare individual who excels at all of them. That is, a surgeon may excel at teaching in the operating room but be much less proficient in a lecture hall or at the patient’s bedside.

The American College of Surgeons recognized this deficiency and established the Surgeons as Educators course to specifically address these shortcomings. Fall 2013 marks the 20th offering of this course. The impact of the deficiency in educational training is compounded by a number of factors affecting our profession. The current generation of trainers is accustomed to instruction based on an apprenticeship model. An effective model when there were no time constraints and with a smaller the body of literature, this model is inefficient when applied in today’s environment. Issues such as duty hour restrictions and increasing medical knowledge force trainers to deliver more information with less direct contact. To be effective, today’s trainers need to incorporate novel

instructional techniques, use more frequent formative assessments, and build more comprehensive and valid summative assessments.

Issues Affecting the Profession

Increasing financial constraints. As noted previously, academic medical centers are now in an era dominated by revenue generation. Cuts in medical reimbursement and declines in federal grants continue in ever increasing intensity. Recognizing their impact on educators, there are also unforeseen effects that continue to surface. In an effort to improve efficiency and safety, patient care increasingly is being delivered using midlevel providers. This organizational change may free trainees from noneducational activities, but it also places an additional barrier in patient care. One can argue that the duties of midlevel providers may translate into more operating room time for the junior resident; paradoxically, inefficiencies in intraoperative teaching may lead to a preference to have the senior residents or fellows, and not the junior resident, involved in the operative procedure. Faculty, pressured to increase clinical productivity, may find that the extra time to instruct a junior trainee is just not cost effective.

Massive expansion in new technology. Technologic advances in CT surgery have increased dramatically over the past 20 years. Although the overall volume of thoracic oncologic surgery has essentially remained stable, there have been considerable advances in diagnostic and therapeutic options. Dissemination of new technology (eg, endoscopic bronchial ultrasound, endoscopic mucosal resection, stereotactic body radiation therapy, and radiofrequency ablation) across different specialties (eg, pulmonology, gastroenterology, radiation oncology, and interventional radiology) fragments the care of the patient, silos specialty interventions, and limits trainees' exposure to such technology. Therapeutic advances, such as robotics, can be associated with a steep learning curve, which has been partially addressed by the development of nonaccredited, industry-sponsored fellowships and weekend courses. If not incorporated into the educational curriculum during residency, the exposure to these technologies may be limited, further compromising the resident's experience.

Technology, public education, and novel medical treatment options have had a profound impact on CT surgery training. Public awareness and medical management of diabetes, hypertension, and hyperlipidemia have decreased the incidence of atherosclerotic vascular disease. Endoluminal approaches to coronary artery disease and thoracic aortic disease have decreased the need for coronary artery bypass surgery or open management of thoracic aneurysmal disease. The emergence of transcatheter aortic valve replacement along with other endovascular technologies portends a decrease in the number of open surgical procedures for valvular heart disease. With changes in

incidence of certain diseases (eg, atherosclerotic heart disease) and development of novel technology, the burden on trainers and trainees is increased, and resident training must adapt to avoid being marginalized. As the curriculum expands, however, there is the risk of simply incorporating the additional content without concomitant improvement in educational efficiency or increased time for learning. Known as "curriculumomegally" this common response to increasing educational needs can overwhelm the trainee.¹⁷

EFFORTS TO ADDRESS THE ISSUES

Efforts to improve CT surgical education must address the barriers presented herein. Important to recognize is that no single idea will resolve the issues described and that there will be barriers at initial implementation. Thus, many ideas may need to be implemented concurrently to address the barriers, and iterative changes will be necessary based on ongoing evaluation. In brief, there is no magic bullet, and we will not get this right the first time.

Similar to the previous section, the intent is to provide an understandable framework of the proposed ideas. Specifically, the proposals are categorized into 3 groups: new training paradigms, new instructional and assessment techniques, and faculty development. Again, like the previous section, there is considerable overlap among groups. Novel concepts will by necessity require faculty development and training, but there are some basic aspects of faculty development that stand apart from the first 2 groups.

New Training Paradigms

Integrated programs and other new training models.

The number of integrated CT surgery residency programs has gradually increased since its inception in 2007. That year, the first applicant out of medical school was accepted at Stanford University. In June 2013, Stanford will graduate its first 2 residents who have completed 6-year integrated residency, and there will be 18 certified integrated residency programs in the United States with approximately 75 residents at some stage of training. The integrated training model remains an experiment, however, inasmuch as none of the residents to date has taken the American Board of Thoracic Surgery qualifying examination or transitioned to practice. In July 2012, the Joint Council on Thoracic Surgery Education (JCTSE) surveyed 50 residents in integrated residency programs; for most of the residents, the experience was positive.* Eighty percent were in their first or second year of residency; overall, they were happy with their career choice and training path. But there were concerns: (1) the operative experience on general surgery rotations remains marginal, (2) the value of "component" operations at different training levels is unclear (eg, R-1

*Personal communication to Ara Asadur Vaporciyan, MD.

performs sternotomy, R-2 cannulates the aorta and right atrium, R-3 does proximal anastomosis, and R-4 does distal anastomosis), (3) the value and responsibility while on nonsurgical rotations are variable, (4) the volume of operative cases in first 3 years of the integrated residency is low, and (5) there is a need for a defined national integrated residency curriculum. An *a priori* concern with integrated residency programs was resident attrition; to date, only 2 residents have dropped out. Ongoing careful analyses of the integrated residency model will be mandatory. Assessment of the progress of the graduates along with JCTSE surveys of residents and faculty is planned for the future.

Other surgical specialties have implemented “integrated” training programs, specifically plastic surgery and vascular surgery. Plastic surgery has 2 training options: an “independent format” requiring 3 years in an accredited surgery residency followed by 3 years in plastic surgery or an “integrated format” in which the medical student matches into a 6-year plastic surgery residency. Over recent years, the trend has been the gradual increase in the popularity of the integrated option in plastic surgery with 56% of the residents training in integrated programs.¹⁸⁻²⁰ With vascular surgery training, there are 42 integrated residency programs out of a total of 107 programs; however, only 3 are exclusively integrated with the remaining 39 offering both traditional and integrated options. Notably, both specialties have preserved their traditional models of training. It is likely that CT surgery will also maintain traditional training pathways. Similar to those in plastic surgery and vascular surgery, a significant number of our trainees make their decision to pursue CT surgical training in the midst of their general surgical training.¹¹

Creation of these integrated programs is likely related to a common etiology. Many specialties have concluded that general surgical training is no longer a relevant prerequisite. In particular, the technical skills acquired during general surgery training are less germane with fewer open surgical procedures coupled to the burden of 5 years of training before specialty training. To address issues related to their training, the general surgery leadership has recently instituted a pilot program at 8 institutions known as Focused Innovation in Surgical Training, which provides core surgical training over the first 3 years followed by transition to specialty training in years 4 and 5. On the basis of the findings of the American Surgical Association’s Blue Ribbon Committee Report on Surgical Education, Focused Innovation in Surgical Training with its schema of core surgical training may address the challenges that have led to the development of integrated training programs.²¹ If a core surgical curriculum can be established with consensus among various stakeholders, then such core training will be of substantive value to surgical specialties along with a parallel reduction in training time.

Competency based medical education. Most current residency training models are time-based; that is, the established curriculum is defined by exposure to clinical material over a set duration. Over the past few years, this paradigm has been increasingly challenged as we face an ever expanding field of knowledge and skills and unequal exposure of clinical materials among programs and trainees. To ensure consistently qualified trainees from our educational programs, we must shift the focus to attaining defined skills (ie, competencies) rather than on the training duration.

In 2010, the Carnegie Foundation (100 years after the initial Carnegie Foundation report on medical education submitted by Flexner) recommended 4 immediate goals to reform medical education: (1) standardization of learning outcomes and individualization of the learning process, (2) integration of formal knowledge and clinical experience, (3) development of habits of inquiry and innovation, and (4) focus on professional identity formation.²² Four years previously, ACGME anticipated this educational shift by laying the foundation for competency-based education. Specifically, ACGME required that residency programs provide instruction and assessment of 6 core competencies (patient care, medical knowledge, practice-based learning and improvement, professionalism, interpersonal communication skills, and systems-based practice). To provide a more comprehensive approach, ACGME has initiated the “Milestone Project” to address the limitations of the previous project. The milestones are “competency based developmental outcome expectations that can be demonstrated progressively by residents and fellows from the beginning of their education through graduation to the unsupervised practice of their specialty.” The 6 core competencies remain, but specialty-specific competencies within each core competency have been defined by committees representing each specialty. In thoracic surgery, an educational committee appointed by the ACGME has been working on the Milestone Project over the past year with an expected implementation date of July 2014 for all thoracic surgery residency programs.

Each program is expected to collect data to determine its resident performance with respect to defined milestones; a summary for each resident is reported biannually to the ACGME. Because these milestones were developed by representatives of the specialty, this initiative is the first step in developing a competency-based education. Attainment of these competencies and fulfilling the milestones will define completion of training, in contradistinction to completion defined as after a predetermined duration.

On the other hand, a list of defined competencies or milestones is not in itself sufficient to change the century-long tradition of surgical education. Many questions remain.

How will we measure attainment of these milestones? Is our initial list of milestones too short or too long? How often should they be updated? Finally, who will pay for the additional training that may be required for the trainee who fails to meet these milestones in a set time? Adequately addressing these concerns will be critical to the success of this initiative.

New Models of Instruction and Assessment

Better more accessible content. The model of a textbook as a means of content delivery is outdated. Innovative methods need to be developed that are up-to-date, easily accessible, and adaptable to different learning styles. The classic model of a teacher-centered approach to education assumes all knowledge resides in the teacher who then disseminates that knowledge to the students. In this model the students do not participate in the learning process and are simply passive recipients of the teacher's knowledge. Textbooks epitomized teacher-centric learning. Competency-based education includes, as a central tenet, a more student-centered approach and thus places a greater responsibility for learning on the student's shoulders.

Because knowledge is constantly expanding, substantial portions of a textbook are outdated by the time they are published. Online educational resources that provide up-to-date organized content will be needed to allow students to find the information they need to learn. Examples that are already in place in general surgery include Surgical Council on Resident Education (SCORE), Comprehensive Online Archived Care Heuristic (COACH), and the Fundamentals of Surgery. Similarly, a comprehensive approach to online educational resources has been constructed for thoracic surgery. Using a content management system, a broad editorial board has identified up-to-date content for each of the requisite topics outlined by the American Board of Thoracic Surgery and those topics defined by the Milestones Project. Various forms of content, including textbooks, published literature, video recordings, online lectures, and Web sites, have been organized by topic and are readily accessible on the Web-based content management system. Although this iteration can be considered the first version, it is clear from piloting data and feedback that this approach is well received.[†]

Similar to advances in content access, the Internet can provide improved methods of performance assessment. Competency-based education provides students with a learning framework, but to learn efficiently students must receive formative feedback. Learner knowledge gaps must be identified so that they can be addressed using the resources provided. Learning management systems can track a learner's progress through a prescribed curriculum

and provide feedback directly to the student and teacher. SCORE includes some basic elements of this form of feedback, but its limitation is in the organization of the assessments. The questions are randomly assigned so that the ability for students to directly query their knowledge in a particular subject is unavailable. Pilot studies using more advanced learning management systems have already been completed. Courses were developed within an open source learning management system called Moodle. The courses are self-paced and are accompanied by focused assessments. Initial evaluation of this project was also very favorable, with participants especially attracted to the self-assessment quiz portions of the courses.[‡]

The assessments linked to the courses must be accessible, formative, reliable, and valid. Accessibility is provided by delivery through a Web-based learning management system. Creating formative assessments requires that each item is accompanied by an explanation to support learning. Simply providing the correct answer is not sufficient; the trainees will need instruction to accompany each question to maximize learning. Reliability is beneficial but not as stringent inasmuch as the goal of these assessments is formative rather than summative. If the assessments were high-stakes, then ensuring a high reliability would be necessary. Still, ensuring some consistency between examinations is beneficial. Learning management systems have embedded psychometrics on assessments. Continued monitoring of the assessments will allow poor-quality items to be removed, improving overall reliability. Finally, validity of the assessments will be continually assessed. An assessment must be focused on the "construct" or educational objective it is intended to measure. Continued evaluation of an assessment tool is possible on a learning management system, and adjustments will need to be made to ensure validity. Producing assessment tools that meet these criteria will take considerable time and effort. Although the Self Education/Self Assessment in Thoracic Surgery can provide some items, many more will need to be developed to address all learning objectives. The final product will be a significant advance in our educational approach.

The delivery of better, more accessible content and assessments addresses many of the barriers discussed earlier. Self-study time does not count toward duty hour restrictions. The adaptability of on-line resources helps address the ever expanding and evolving body of knowledge. The centralized nature of the resources alleviates some of the burden on local trainers. However, similar to any new solution, this one adds some new barriers. The most obvious is, who will produce and maintain the content libraries and the courses? Resources will have to be

[†] Personal communication to Craig Baker, MD.

[‡] Personal communication to Ara Asadur Vaporciyan, MD.

allocated and some form of administration will be required. These barriers may be difficult to overcome, but maintaining the status quo will not be an alternative.

Simulation. The ability to practice a skill before the live performance has been accepted as a standard in many domains. Surgical simulation provides deliberated and distributed practice in a less stressful environment and may enable graduated training of technical skills and crisis management. Simulation-based learning is commonly used at the local level within simulation centers embedded in many training programs. To date, there remains substantial variability in terms of organization and implementation. In general surgery, structured approaches have been developed, such as the Fundamentals of Laparoscopic Surgery, which involves a standardized curriculum, a technical skills model, and formal assessment standards. The Fundamentals of Laparoscopic Surgery is mandated by the American Board of Surgery and many credentialing organizations around the world.

The CT surgery community has developed focused programs to advance and formalize simulation-based learning, the first of which was the Thoracic Surgery Foundation for Research and Education Visioning Conference in 2007.²³ Since 2008, the Thoracic Surgery Directors Association has conducted an annual Boot Camp for one third of all first-year conventional CT surgery residents with training focused on cardiopulmonary bypass, vessel anastomosis, aortic valve surgery, bronchoscopy and mediastinoscopy, and pulmonary resection using synthetic and tissue-based partial task trainers and high-fidelity, whole-task simulators.²⁴ Boot Camp has also directed resources to develop novel simulators and assessment tools and establish a venue to educate faculty in simulation-based learning. To increase the group of expert educators in resident training is the basis for the “Senior Tour,” which currently comprises more than 20 retired CT surgical educators who can assist in surgical skills training using simulation and programmatic evaluation.²⁵ In addition, the JCTSE and Thoracic Surgery Directors Association have developed a 92-page simulation curriculum to serve as a template for simulation training. Furthermore, a 42-week syllabus based on 6 modules, including intraoperative crisis management, is being developed by a cardiac surgery study group sponsored by the Agency for Healthcare Research and Quality. These efforts have led to the refinement of the simulators and the development of performance assessment tools. Currently, the Thoracic Surgery Residency Review Committee has mandated that all residency programs include some form of simulation training, and the American Board of Thoracic Surgery has mandated that residents have a minimum of 20 hours of simulation training during their residency.

Despite perceived benefits of technical skills training using simulation, there are concerns regarding the logistics

and time commitment of such an approach. Simulation sessions, when scheduled, count toward resident duty hours and may conflict with clinical responsibilities. Along with the cost of running a simulation laboratory, faculty frequently are not financially compensated for teaching in a simulation setting. Without defined structure, robust curriculum, and formative feedback, the efficacy of simulation can be questioned. Nonetheless, exposure to rare and potentially catastrophic events, such as the difficult or obstructed airway, vascular injury during lobectomy, massive air embolus during cardiopulmonary bypass, and intraoperative aortic dissection, without any danger to a patient are of substantive benefit and serve as the basis for the broader application of simulation both for training and assessment.

Faculty Development

Improve teaching effectiveness. Expertise is not transferable across domains.²⁶ Excellence as a surgeon does not imply excellence as a surgical educator. Several training sources are available at both the local and national levels (Table 1). The American College of Surgeons recognized this and began an effort to educate surgeons in how to teach effectively. Their 6-day course titled “Surgeons as Educators” addressed issues as teaching skills both in and out of the operating room, curriculum development, educational administration and leadership, and performance and program evaluation. Recently the JCTSE established a similar but shortened version of the same course for CT surgery educators. Additional efforts such as minisymposiums and courses at both our national meetings have also been used to reach a broad group of faculty.

All of these efforts have been aligned with many of the changes that are being introduced such as the Milestones project. However, more important, they are also focused on developing more effective teachers. No matter what major changes we implement in resident training, the most effective learning will still take place one-on-one between a trainee and a teacher at the bedside or in the operating room. These efforts are designed to maximize those encounters.

Faculty incentives. If we are to truly engage our faculty as educators, we must allow their effort to be recognized and rewarded. In light of the barriers discussed earlier, the pressures on surgical educators to produce measurable value, either as clinical volume or publications and grants, is the overwhelming incentive currently in place. If education is to grow in importance, there must be some way to measure its value and reward scholarly activity in education appropriately. Two methods of faculty rewards exist. The first is to reward high-quality education as a scholarly activity in itself and the second is to use the existing reward system of publications and produce conventional scholarly work in education.

TABLE 1. Summary of training opportunities in surgical education

Curriculum	Specific program examples	Sponsoring organization
Immersion courses	“Surgeons as Educators”	ACS
	“The Program for Educators in Health Professions”; “The Leading Innovations in Health Care and Education Program”; and “The Leading Innovations in Health Care and Education Program”	Harvard Macy Institute
	“Educate the Educators”	JCTSE
	“Essential Skills in Medical Education”	AMEE
	Masters of Educational for Health Professionals (advanced degree)	Local university and on-line degrees
Faculty development courses at national meetings	“Surgical Education”	ACS Fall Clinical Congress
	“Faculty Development Workshop”	APDS Annual Meeting
	“Thoracic Surgical Education Seminars”	JCTSE; STS and AATS annual meetings
Sponsored fellowships	Surgical Education Research Fellowship	ASE
	International Fellowship in Medical Education	FAIMER
	Medical Education Fellowship	IAMSE
	Academy for Innovation in Medical Education	AIME/uOSSC
	TSFRE Grants, Fellowships, and Scholarships	TSFRE
Simulation opportunities	SimPORTAL Simulation Fellowship	University of Minnesota
	Simulation Instructorship Program	Northwestern University
	Schwartz-Reisman Fellowship in Simulation Medicine	Mayo Clinic
	Annual Boot Camp	TSDA and JCTSE

ACS, American College of Surgeons; JCTSE, Joint Council on Thoracic Surgery Education; AMEE, Association for Medical Education in Europe; APDS, Association of Program Directors in Surgery; STS, The Society of Thoracic Surgeons; AATS, The American Association for Thoracic Surgery; ASE, Association for Surgical Education; FAIMER, Foundation for Advancement of International Medical Education and Research; IAMSE, International Association of Medical Science Educators; AIME, Academy for Innovation in Medical Education; uOSSC, University of Ottawa Skills and Simulation Center; TSFRE, Thoracic Surgery Foundation for Research and Education; SimPORTAL, Simulation Perioperative Resource for Training and Learning; TSDA, Thoracic Surgery Directors Association. Adapted from Linderman B, Yang SC. Training opportunities in medical and surgical education. In: Sippel RS, Pugh CM, eds. *Success in Academic Surgery: Developing a Career in Surgical Education*. New York, NY: Springer; 2013.

Many institutions have implemented educator tracks for promotion. These require a mechanism for assessing the quality of education. Although conventional publications presented within a curriculum vitae are used, many turn to the use of an educational portfolio to document educational effort. These documents are similar to an artist's portfolio and provide evidence of the quality of work being produced. The level of achievement required to advance along these pathways varies greatly between institutions. In support of these pathways, the JCTSE is creating an “Innovators in Thoracic Surgery Education” academy. Membership will be dependent on an individual demonstrating a sustained educational commitment in practice. Additional competitive awards to provide recognition in education at the national level will need to be developed to support academic advancement in this pathway.

Most surgeons also do not realize that education is a science with its own literature, language, protocols, and research standards. In fact, with duty hour restrictions, variability in curriculum, available on-line resource, and cognitive challenges facing surgical education, this is a rich time for publishable research. In many ways, this research in 2013 is less expensive than basic science research and easier to publish. Both American flagship journals in CT surgery are committed to publishing articles specifically addressing educational issues. Although grant support is limited, there are many novel philanthropic organizations that focus on education, inasmuch as this

obviates the need to purchase expensive reagents or equipment. The availability of dedicated masters programs in health professions education also allows one to focus a career path in educational research.

SUMMARY

The model of surgical training in the United States has changed little in the past 100 years. Unfortunately, numerous new barriers have arisen that challenge this system and call into question its continued ability to train future members of our profession. Many new ideas have been developed and implemented to address one or many of these barriers. The solution will not be a solitary one nor will it come with our initial efforts; the perfect system likely will not be attainable. Rather, continued experimentation and evaluation, introduction of new techniques, and adaptation of existing techniques must take place. A critical mass of interested surgeons and educators will be needed to accomplish these objectives. After nearly a century of little change in the delivery and assessment of surgical training, we are now poised to revolutionize our educational methods while improving our training results despite the challenges we now face.

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