Current Problems in Surgery 56 (2019) 174–197

Contents lists available at ScienceDirect

Current Problems in Surgery

journal homepage: www.elsevier.com/locate/cpsurg

General surgery residency: Past, present and future

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For understandable reasons, general surgery residency may seem almost monolithic—solid and unwavering. In reality, though, nothing could be farther from the truth. The structure, curriculum, programs, teaching methodology, and residents of general surgery training have undergone continual evolution and will continue to evolve in the future. In order to conceive of the future of education in general surgery, it is necessary to understand its past, its present, and trends that link the 2. It is also essential to examine some of the current and potential, future challenges in the education of general surgery residents.

Beginnings

What came to be the United States was devoid of formal surgical training for almost 3 centuries after colonization. Individuals learned what little surgery they could through apprenticeship. Those with the means to do so supplemented that learning with visits to the clinics of well-known European surgeons. The first formal training in surgery in the United States began at The Johns Hopkins Hospital under the direction of William Steward Halsted in 1889.[1] In Halsted's system, the residents (who, in fact, were residents on the hospital property) worked on the wards and in the operating room but were also expected to have ongoing research in important topics of the day, such as anatomy, physiology, and bacteriology. Approximately 8 individuals entered training each year. Half of those were dismissed after only 1 year. The remainder stayed in the program for varying lengths of time in the hope of becoming the House Surgeon (chief resident). Very few actually achieved that distinction. One became the chief resident only when Dr. Halsted deemed one ready. On average, that occurred after approximately 8 years of training. In the 32 years that Halsted was Chief of Surgery at Johns Hopkins, only 17 individuals rose to be House Surgeon. Along the way, then, most of the individuals who were residents under Dr. Halsted left the program (voluntarily or involuntarily). The program that he established was actually more a formalized apprenticeship than a residency as we know it today. It

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https://doi.org/10.1067/j.cpsurg.2019.01.005
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Table 1
Year of establishment of surgical member boards of the American Board of Medical Specialties (ABMS).

1916	American Board of Ophthalmology
1924	American Board of Otolaryngology (now Otolaryngology, Head and Neck Surgery)
1931	American Board of Obstetrics & Gynecology
1934	American Board of Orthopedic Surgery
1935	American Board of Proctology (now Colon and Rectal Surgery)
1935	American Board of Urology
1937	American Board of Surgery
1940	American Board of Neurological Surgery
1941	American Board of Plastic Surgery
1971	American Board of Thoracic Surgery

was utterly hierarchical and steeply pyramidal. Although several individuals who trained in his program went on to become professors of surgery at the leading hospitals of the day and to establish their own training programs, most left the Halsted program to enter practice as partially trained surgeons. Very much to his credit, Dr. Halsted did invoke a system of graded, progressive authority based on the demonstrated ability of a given resident. The Halsted "residency" was not immediately accepted by other hospitals and surgeons. Indeed, there were institutions that today have some of the better known training programs in the country which did not establish residency programs until the 1940s. The Massachusetts General Hospital was one institution which did embrace the residency training model and subsequently provided a key innovation toward the development of the modern residency program.

Edward Churchill recognized the untoward effects of the majority of individuals who entered surgical residency leaving a program when only partially trained. He famously noted that, "Half a surgical training is about as useful as half a billiard ball." He conceived the "rectangular" residency in which each individual entering the program was expected to remain in the program for 5 years and leave the program a fully trained surgeon. Although the idea occurred to him in the late 1930s, it was not implemented at the Massachusetts General Hospital until Churchill's return from his service in the Second World War.[2]

In Halsted's early years, a surgeon was a surgeon and did all things then surgically possible. Along the way, individuals began to specialize in particular aspects of surgery. That trend is probably best documented by the establishment of the certifying surgical boards, beginning with the American Board of Ophthalmology in 1916 (Table 1).

Approval/accreditation of programs

The Council on Medical Education of the American Medical Association (AMA) established an approval process for internships in 1914. In 1925, the AMA published its first list of hospitals approved for residency training and in 1933 it published a document titled, "Essentials in a Hospital Approved for Residents in the Specialties."[3] In 1939, the American College of Surgeons (ACS) established criteria for graduate training in surgery and a process for approving surgical residency programs.[4] The approval processes of the AMA and the ACS were created and managed entirely separate from one another. Thus, there were then 2 separate agencies offering parallel but very different approval processes for surgical residencies. A hospital could choose to be approved by one, the other, both, or neither. One can only imagine the consternation of the hospitals and surgeons, therein, that attempted to meet 2 disparate sets of training standards. The public must have found this utterly confusing, as well. Fortunately, those approval processes lived in parallel for only 11 years. In 1950, the American Board of Surgery (ABS), the ACS, and the AMA joined forces to create the Conference Committee on Graduate Training in Surgery in order to establish a single set of standards to govern surgical training.[5] A similar conference committee had been established for internal medicine approximately 1 year earlier and, following surgery, the model was replicated by other surgical specialties throughout the 1950s. As

specialization and specialty training became more pervasive and diffuse, the call went out for the establishment of a body to oversee the overseers of what was by now known as graduate medical education. The goal was to bring some degree of uniformity to the format and language of the training standards for different specialties while eliminating outright contradictory standards. To this end, the American Association of Medical Colleges (AAMC), the American Board of Medical Specialties, the American Hospital Association, the AMA, and the Council of Medical Specialty Societies joined forces to establish the Liaison Committee for Graduate Medical Education (LCGME) in 1972.[3] The LCGME began to accredit programs in 1975, with delegation of the authority to render the actual accreditation decisions to the newly created residency review committees in the various specialties. The members of the Residency Review Committee for Surgery (RRC-Surgery) were appointed by the same organizations that had established the Conference Committee, namely the ABS, the ACS, and the AMA.[5] The structure and politics of the LCGME were arcane and its deliberations were ponderous resulting in almost monumental inaction.[6] Frustrated with the LCGME, the ACS Board of Regents authorized in 1978 exploration of a new mechanism for the approval of GME programs in surgical specialties.[7] By 1980, the position of the ACS was supported by the Council of Medical Specialty Societies.[6] Increasing momentum for change in the governance of graduate medical education resulted in the replacement of the LCGME in 1981 by the Accreditation Council for Graduate Medical Education (ACGME). The parent organizations of the ACGME were the same as those of the LCGME. On paper, the structure of the ACGME was quite different from that of the LCGME. Unfortunately, the new organization proved to be only slightly more administratively nimble and responsive than its predecessor and was fraught with political intrigue. The growing frustration of the parent organizations, themselves, led to the recognition that yet another governance structure was necessary. In 2000, the new ACGME was established.[8] As opposed to being a council of the AMA, the new ACGME was as a not-for-profit corporate entity governed by a board of directors. While that board was comprised largely of nominees from the same 5 organizations that had parented the LCGME and the previous ACGME, the actions of the new ACGME were no longer subject to the veto of any 1 of those organizations. Despite radically different structure and governance, the new organization retained the name of ACGME because there was no appetite to attempt to alter the important federal regulations which recognized an entity of that name (personal communication with Doug Carlson, Esq. who authored and filed the articles of incorporation). Since 2000, the ACGME board of directors has been expanded to include public members, at large physician members, the Chair of the Council of Review Committee Chairs, 2 resident members, and 2 nonvoting representatives of the federal government. Most recently, the American Association of Colleges of Osteopathic Medicine and the American Osteopathic Association have joined the original 5 as member organizations.[9] The role of the Review Committees has changed very little since the 1972 formation of the LCGME. They make decisions regarding the accreditation of programs through authority delegated to them by the parent organization and they can propose program requirements, subject to modification and approval by the ACGME Board of Directors.

Program structure

The first ACS training standards called for, “Duration of Training: A period of at least 2 years, but preferably 3 or more years, in graduate training for general surgery or a surgical specialty”.[4] As of July 1950, the ABS allowed 2 training paradigms. “Group I” programs consisted of 1 year of internship and a minimum of 4 years of training in surgery in an institution acceptable to the board. One year could be spent in a surgical specialty or experimental surgery or research. “Group II: The board will…recognize 3 years of residency in (an institution) acceptable to the board, followed by 2 years of study or practice of surgery, during which time sufficient operative experience to meet the board’s requirements must be obtained. The latter 2 years must be taken under the supervision of a surgeon certified by or acceptable to the board, and carrying on his practice in hospitals approved as meeting the minimum hospital requirements of

the ACS. Not more than 2 of the 5 years required by Group II applicants may be spent in the subspecialties of surgery."[10] By 1971, the ABS required a minimum of 4 years of surgical training following the awarding of the MD degree, thus eliminating the requirement for a rotating internship.[11] Group II programs were discontinued as of July 1, 1972.[11] By 1983-1984, the requirement changed to a minimum of 5 years of graduate training in surgery after medical school, of which at least 4 years had to be clinical experience with a minimum of 3½ years (including the entire final year) devoted to the principal components of general surgery.[12] Currently, there is a minimum requirement 54 months of clinical surgery within the 5 years with at least 42 of those 54 months devoted to the principal components of general surgery.[13]

The requirements for the chief (final) year of residency have undergone important incremental changes. That experience was specifically defined in the program requirements effective July 1984 as consisting of 12 consecutive months of clinical experience in multiple areas of the principal components with no more than 4 months devoted exclusively to any 1 of those components.[14] In the requirements effective 1990, it was specified that the chief year be served entirely at the parent or integrated institutions except that a rotation on a pediatric surgery service could be performed if it met certain criteria set forth by the RRC.[15] In 1999, it became possible to take advantage of a unique educational opportunity by serving a portion of the chief year during the fourth clinical year with prior approval from the RRC.[16] Effective 2008, a 6 month limit on the portion of the chief year that could be served in the fourth clinical year was established and it was clearly specified that operative cases counted as chief cases must be performed during the 12 months designated as the chief year.[17]

Minimum operative case requirements

Early ABS and program requirements spoke generally to the number of surgical patients necessary to provide residents with "sufficient operative experience." It was not until 1983, though, that a minimum number of operative cases for surgical residents was even suggested. The 1983-1984 Special Requirements stated, "While the number of operations to be performed by each resident is not specified, experience has shown that an acceptable range, in most instances, is from 500 to 800 total cases and from 150 to 300 cases as the "Surgeon, Senior Year."[12] By 1990, the "acceptable range" of major operations was increased to 500-1000 for all years while remaining at 150-300 in the chief year.[18] Also by 1990, the RRC-Surgery had established minima for certain categories of operations such as endocrine, vascular, alimentary, and abdominal corresponding to the "primary components" of general surgery. Interestingly, the categorical minima have never been specified in the Program Requirements and their existence was not even noted in the Program Requirements for almost 2 decades after their creation.[17] The categorical minima were initially conveyed in RRC newsletters to program directors and more recently have been specified on the ACGME website. Furthermore, it was not until 2008 that minimum overall case numbers were specified in the Program Requirements with those being 750 total major cases and 150 of those being performed in the chief year.[17] In 2018, the minimum was increased to 850 total major cases with a minimum of 200 cases as chief.[13]

An incredibly important aspect of surgical residency is the opportunity to serve as the teaching assistant to more junior residents. The role of the teaching assistant was first acknowledged in the Special Requirements of 1983-1984 which stated, "Provided that previous personal operative experience has been adequate, cases listed as "teaching assistants" may be credited toward chief year requirements."[12] The 2003 Program Requirements stated that both postgraduate year (PGY)-4's and PGY-5's could act as teaching assistant but did not specify how those cases might be counted.[19] Further evolution of the teaching assistant role occurred in the 2007 Program Requirements which stated that only PGY-5's could act as teaching assistant for credit and further specified that up to 50 teaching assistant cases could count toward the total case requirement (but not toward the chief resident case requirement).[20] In its 2013-2014 Booklet of Information, the ABS stated that, "Applicants who completed residency in the 2014-2015 academic year or thereafter must have participated as teaching assistant in a minimum of 25 cases

by the end of residency."[21] and the current Program Requirements in Surgery conform to that requirement.[13]

Although submission of operative case logs has been a part of the ABS application for entry into the certification process for decades, it was not until 1989 that programs were required to report the cases of completing residents to the RRC-Surgery.[22] Initially, programs submitted those data to the RRC-Surgery electronically on computer floppy disks and a "cottage industry" was born of companies selling software to create those diskettes. The ACGME created an on-line mechanism for residents to log cases in real-time which became available in 2001 and its use has been required since 2005.[23]

Simulation

Simulation has been utilized in surgical education since (at least) the first time an intern wrapped a strand of heavy-gauge silk suture around a chair arm to practice tying square knots. Perhaps the first systematic utilization of simulation in a surgical curriculum came about with the Advanced Trauma Life Support (ATLS) course.[24] With the exception of ATLS, simulation in most surgery residency programs was done informally on an ad hoc basis until the laparoscopic revolution.[25] The word "simulation" did not appear in the Program Requirements for General Surgery until 2008 at which time the requirement was simply that, "Resources should include simulation and skills laboratories."[17] Of course, the presence of a skills lab is of no value unless it is utilized in an intentional manner. Perhaps that concept was best captured by Satava who wrote, "It is crucial to understand that simulation is a tool, not an end in itself. It's all about the curriculum…"[26] To that end, the Review Committee for Surgery made an important addendum to the Program Requirements in Surgery in 2012 by stating, "These (simulation) facilities must address acquisition and maintenance of skills with a competency-based method of evaluation".[27] The ABS now requires completion of both the Fundamentals of Laparoscopic Surgery and the Fundamentals of Endoscopic Surgery courses as prerequisites for entering the certification process.[28] Like ATLS, both of these courses entail substantial simulation activities. Thus, while there is no registry that tracks the facilities for simulation in each general surgery program, the simulation curriculum in each program or the utilization of simulation facilities in each program, it is clear that there has been a trend toward greater utilization of simulation in general surgery residency in recent decades.

Progressive responsibility

Progressive responsibility and authority was 1 of the principles of Dr Halsted's residency program and remains 1 of the core tenants of American graduate medical education.[29] From the earliest days of the Conference Committee on Graduate Training in Surgery, the requirements for training of the ABS spoke to "increasing responsibility," "a high degree of responsibility," and "a graded residency".[10] As the oversight of graduate medical education migrated to the LCGME, the "General Requirements" for graduate medical education repeatedly referenced "graded and progressive responsibility for patient care". Speaking to surgery, those "General Requirements" stated, "During the course of his training, the resident should be given sufficient operating responsibility to acquire surgical skill and judgment. This experience should be progressively graded to the end that, on completion of his training, the resident is able to assume individual responsibility for major surgical procedures."[30] In the era of the original ACGME, the Specialty Requirements for Residency Education Training in General Surgery called for "a chain of command that emphasizes authority and increasing responsibility as experience is gained" and stated that, "Proper supervision must not conflict with progressively more independent decision making on the part of the resident."[15] Now under the aegis of the modern ACGME, the current Program Requirements in Surgery continue to call for "progressive responsibility for patient management" and "graded levels of responsibility…achieved for each resident."[13]

Duty hours

With the advent of the LCGME, what had been a completely independent Conference Committee on Graduate Training in Surgery became a Residency Review Committee and ceded ultimate approval of program requirements and accreditation decisions to that governing body. Nevertheless, the LCGME and the original ACGME made little or no effort to originate requirements by which surgery programs would be governed. However, shortly after formation of the "new" ACGME in 2000 work began on what would be called "Common Program Requirements" which would be applicable to all specialties and subspecialties accredited by the ACGME.[31] The Common Program Requirements were designed to contain fundamental educational principles, policies, and procedures applicable to all GME programs. It was mandated that every Residency Review Committee, including Surgery, accept and incorporate the Common Program Requirements with the important proviso that although an RRC could not make any of those requirements less restrictive they could make any of them more restrictive and, in that way, enumerate those requirements they deemed necessary for the training of individuals in their specialties and subspecialties. An element of those original Common Program Requirements which, at the time, led to a lot of confusion and a little consternation in the surgical community was the introduction of the "competencies." An element which led to little confusion but great consternation in the surgical community was the restriction of resident and fellow duty hours. At that time, there was no credible evidence that resident fatigue resulted in patient (or resident) harm. However, there was nascent evidence that fatigue resulted in increased mental and physical errors.[32] At least equally importantly, federal legislation had been introduced by Representative Conyers which would have resulted in government regulation of resident duty hours along with public reporting of violations.[33] For both moral and practical reasons, the ACGME Board of Directors felt compelled to limit the hours which a resident or fellow could work. The specific restrictions on resident work hours have undergone changes with each major revision of the Common Program Requirements since 2004.[29,34,35] The most notable of those changes was the restriction of PGY-1's to a maximum of 16 continuous duty hours in the iteration of the Common Program Requirements that became effective in 2011.[29] Following a carefully designed and highly subscribed trial focusing on patient outcomes[36] that restriction has since been removed.[35]

The programs

Between the 2001-2002 and 2014-2015 academic years, the number of ACGME-accredited general surgery residency programs remained fairly stable, waxing and waning between 248 and 256[37] (Fig. 1). Nevertheless, the number of residents in those programs rose from 7249 to 7732 over the same period due to an increase of approximately 1.7 residents per program (Fig. 2) On July 1, 2015 the move to a single GME accreditation system began.[38] In this transition, programs that were previously accredited by the American Osteopathic Association (AOA) could apply for ACGME accreditation through a modified application process. Largely as a result of that transition, the number of ACGME-accredited surgery programs increased from 256 in 2014-2015 to 301 in 2017-2018 and the total number of residents increased from 7732 to 8475 over the same short period[37] (Fig 2). The smaller size of the previously AOA accredited programs is reflected in the fact that after more than a decade of increasing, the mean number of residents per program is now less than it was in 2001-2002 (Fig. 3). Despite the transition of the previously AOA accredited programs, the general trend toward larger programs continues to be reflected in the mean number of clinical sites utilized per program which has increased from 4.02 in 2006-2007 to 4.8 in 2017-2018 (Fig. 4). The mean number of faculty members designated per program has been tracked by the ACGME only for the past 3 years and currently stands at 34.2.[37] Longer-term trend data are available from the annual AAMC Faculty Roster survey. The total number of physician faculty members in departments of surgery in AAMC member schools increased from 8846 in 2010[39] to 15,710 in 2017.[40] To be sure, there are many ACGME-accredited

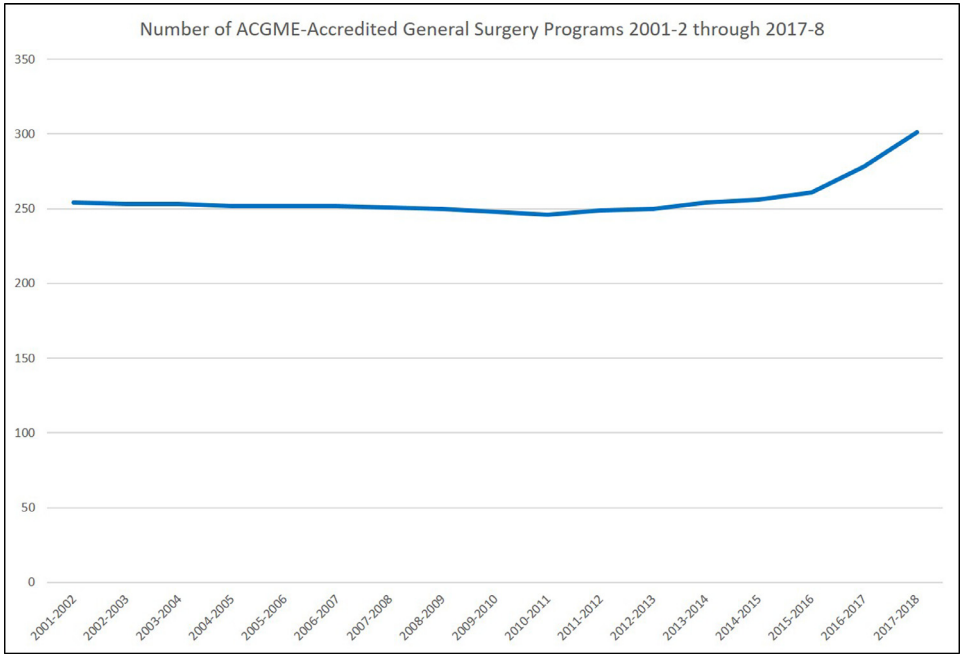

Fig. 1. Number of Accreditation Council for Graduate Medical Education-accredited general surgery programs from 2001-2002 to 2017-2018. There was no significant change in the number of programs prior to the 2015-2016 year. The vast majority of the programs accredited since 2015-2016 have transitioned from American Osteopathic Association accreditation.[37]

surgery programs are not associated with medical schools. Still, these data clearly represent a trend of enormous growth in the number of faculty members per program. The final trend with respect to the programs is that the mean tenure of the program directors has declined from 7.2 years to 6.9 years over the last decade.[37] Although seemingly small, this decrease is statistically significant.

The residents

One very significant objective change in the residents in surgery programs has been growth in the proportion of female residents. In 2002-2003, 22% of surgery residents were female. In 2017-2018 37.9% were female[37] (Fig. 5). Another very recent and significant change in general surgery residents in ACGME-accredited programs is the increase in proportion of residents who attended osteopathic medical schools. That figure, which was approximately 3% until 2012-2013, now approaches 10%[37] (Fig. 6). This change in medical schools of origin is largely (if not entirely) due to the transition to a single GME accreditation system.

Resident ethnicity has been tracked by the ACGME only since the 2011-2012 academic year and is collected on a voluntary basis with a relatively limited menu of options. In the 7 years for which data are available there has been no significant change in the proportion of surgery residents who are white, non-Hispanic (approximately 46%), Asian or Pacific Islander (approximately 12%), Hispanic (approximately 5%), Black, non-Hispanic (approximately 5%), or Native American/Alaskan (less than 1%). Indeed, the only significant changes are a decrease in “other” (now approximately 5%) and an increase in “unknown” (now approximately 29%)[37] (Fig. 7). The mean age of residents entering the PGY-1 year of general surgery programs has remained approximately 29.2 years.[37]

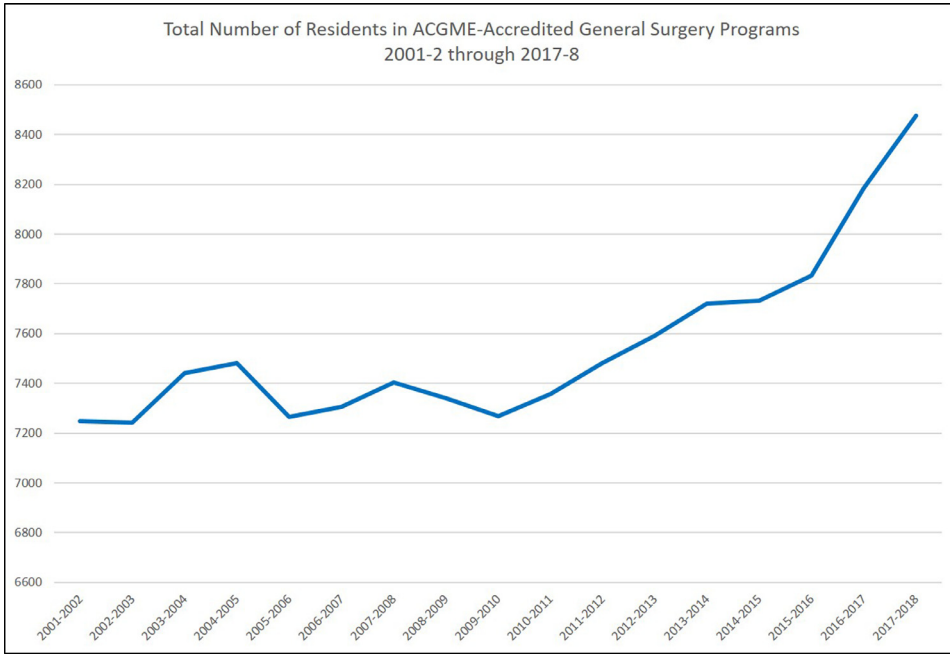

Fig. 2. Total number of residents enrolled in Accreditation Council for Graduate Medical Education-accredited general surgery programs 2001-2002 through 2017-2018.[37] There was a significant increase in the number of residents between 2001-2002 and 2014-2015 ($P = 0.003$). The marked increase since 2014-2015 is due primarily to the transition of programs that were previously American Osteopathic Association accredited.

Current challenges to general surgery resident education

It is generally agreed that medical school graduates are less prepared to enter general surgery residency now than they were in the past.[41-43] Although that diminished preparation is certainly multifactorial, 2 contributing factors are frequently cited. The first is that most medical schools have done away with night call for students, thus leaving them unprepared for the rigors of surgical residency. The second is that, in the era of the electronic medical record, medical students gain little to no experience in documenting histories and physical examinations, writing progress notes, writing discharge summaries, and writing orders. Although there are some very good reasons for their existence, resident duty hour limitations have had, and continue to have, several negative effects on resident education. Most teaching hospitals did not increase ancillary staff when duty hour regulations came into effect and many have not yet adequately done so.[44,45] As a result of duty hour restrictions, the same amount of patient care "work" must be done by residents in fewer hours. A resulting manifestation of this in the surgical specialties is that there is less time for residents to be in the operating room to simply observe and learn when they are not, themselves, performing operations. Another result is that some programs eliminated valuable rotations outside of the sponsoring institution simply to enhance the workforce therein. The duty hour restrictions have also forced more resident "hand-offs" of clinical care. Although giving and receiving patient "hand-offs" are valuable and necessary skills to learn, there is a sense among more senior faculty members that residents no longer feel the same level of personal responsibility to the patients in whose care they are privileged to participate that residents once had.[46-48] Another challenge to modern resident education is that for financial, historical, and other reasons, residency remains hospital based at a time when so much of the practice of general surgery (certainly including operations) has moved to the outpatient arena.[49]

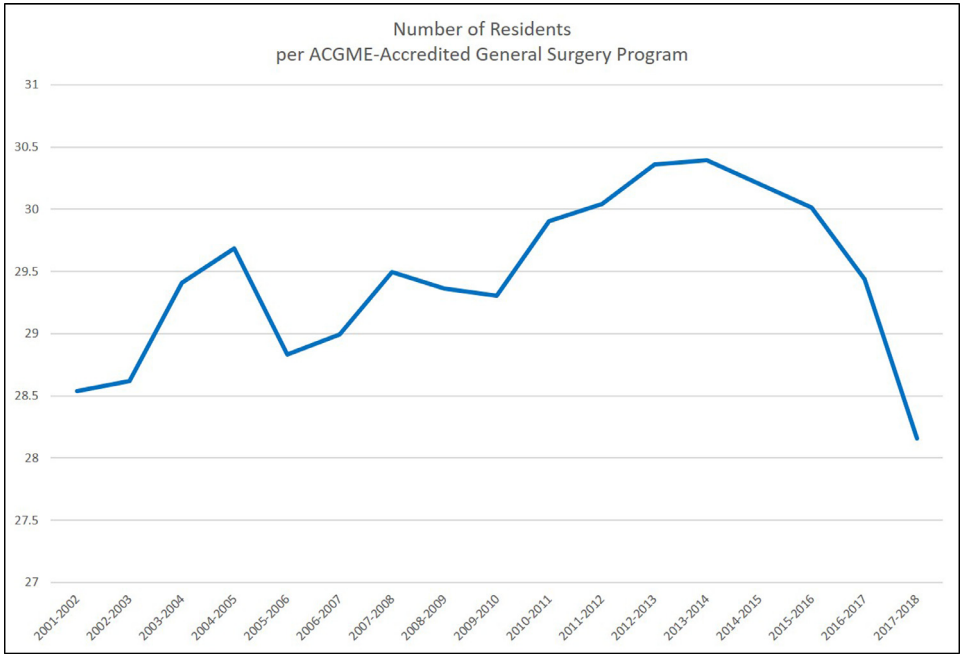

Fig. 3. Mean number of residents per Accreditation Council for Graduate Medical Education-accredited general surgery program. The mean number of residents per program slowly but steadily increased for more than a decade. Due primarily to programs transitioning from American Osteopathic Association accreditation, the mean number of residents per program is now less than it was in 2001-2002.[37]

Until the laparoscopic revolution of the 1990s,[24] general surgery residents had 5 years to learn the techniques of open operations. Now, with no expansion of the duration of residency, they must learn open *and* laparoscopic techniques as well as some fundamentals of robotic surgery. In addition to changing techniques of operations, the diseases and conditions treated by surgeons have changed.[49] This, coupled with the ever-expanding detailed knowledge of both common and uncommon diseases and the treatments thereof, challenges the maintenance of a comprehensive but comprehensible curriculum. Teaching methodologies which are both effective and preferred by today's learners are certainly available and fairly readily so. However, most formal teaching in most residency programs is still done by the "sage on the stage" as it was a century ago. Faculty development in fundamental topics of education such as teaching methodologies, evaluation and feedback is also readily available, but participation in faculty development is not seen as a priority for most faculty members.[50]

The role of the program director is incredibly complex. As of July 2018, the Program Requirements for Resident Education in General Surgery contained more than 45 "musts" which applied directly to the duties of the program director and dozens of other "musts" for which the program director is ultimately responsible.[13] Furthermore, many duties for which the program director is responsible in most programs and which are arguably as important to the program are *not* listed in the Program Requirements. The "Model Position Description" of the responsibilities of a residency program director from 1 institution lists more than 70 distinct duties of a program director, of which only a minority are directly related to ACGME requirements.[51] Perhaps foremost among those duties is the selection and recruitment of residents who are suitable for the program. It takes years for most individuals to fully understand and effectively carry out the written and unwritten duties of the program director. It is, therefore, concerning that the mean tenure of general surgery program directors is significantly declining.

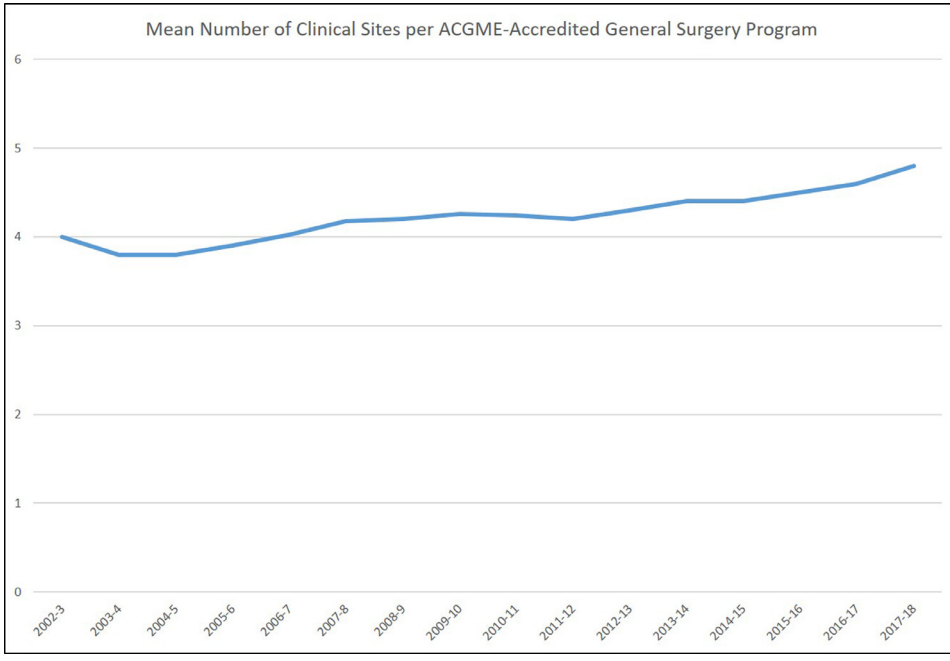

Fig. 4. Mean number of clinical sites per program.[37] The increase in the mean number of clinical sites per program over the last 15 years is statistically significant. ($P < 0.001$).

The adage that "bigger is better" may apply in many settings is not necessarily true in the education of surgical residents.[52] General surgery residency programs have demonstrably grown in the number of residents, the clinical sites to which residents rotate, and the number of faculty members. This growth may well offer such advantages as an increased number and complexity of operations and greater scheduling flexibility to accommodate the desires or needs of specific residents. However, those advantages come at a price. The more residents, attending surgeons, and clinical sites there are in a program the less time the program director and other faculty members spend with each resident. They are, therefore, less familiar with the experience and capability of any given resident. Therefore, they are less able to properly evaluate each resident, less able to provide appropriate feedback to each resident, and less able to provide learning opportunities that meet specific needs of each resident. Another unfortunate consequence of growth in the number of clinical sites and faculty members in a program is that faculty members often have the expectation of "resident coverage" for each of their operations. All too often this results in residents running from room-to-room to scrub into operations for which they are little prepared. It also results in junior residents being thrust into "doing" operations which they have never before seen and on which they have never before served as an assistant. Another result of the dilution of the resident pool to many sites and many attending surgeons is that the opportunity is lost for senior residents to act as teaching assistant to more junior residents. The decrease in the number of cases on which residents serve as first assistant and as teaching assistant is not only statistically significant but dramatic[23,53] (Fig. 8). That loss of first assistant and teaching assistant cases substantially truncates important early and late operative experience and resident learning.

Fellowship programs in derivative subspecialties of general surgery have exponentially proliferated in number and variety[37] (Fig. 9). The vast majority of those programs coexist in the same institutions as general surgery residency programs. Certain advantages may accrue from those fellowship programs such as the recruitment of more and more complex operations and

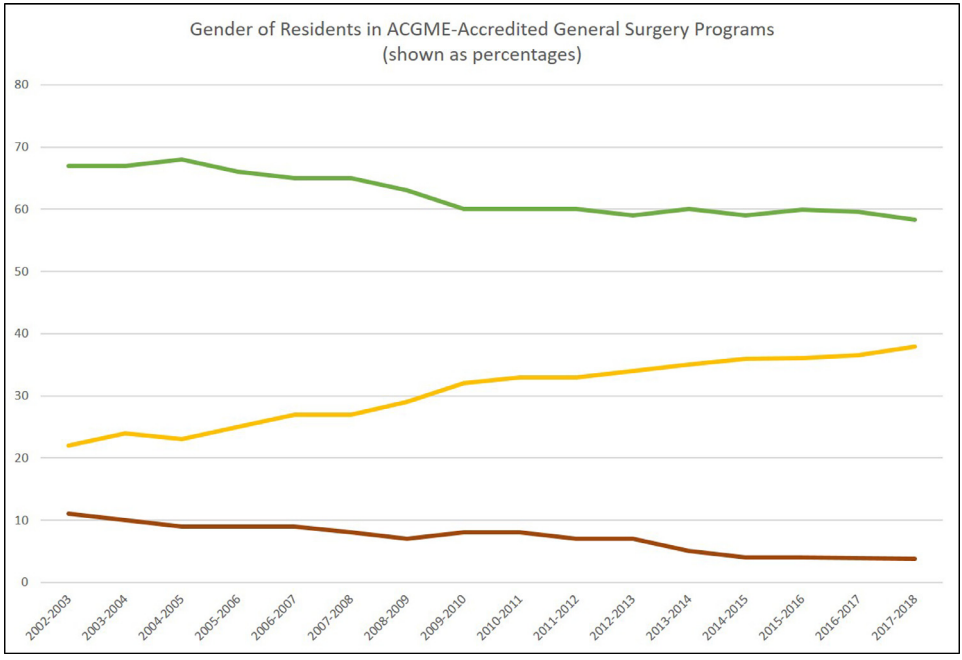

Fig. 5. Gender of residents in Accreditation Council for Graduate Medical Education-accredited general surgery programs (shown as percentages).[37] Resident gender is self-reported on a voluntary basis. Since the 2002-2003 academic year, the percentage of male residents and the percentage of residents not reporting gender (NR) have both significantly declined. ($P < 0.001$) while the percentage of female residents has significantly increased. ($P < 0.001$).

the near-peer teaching of residents by fellows. However, one would intuitively expect that those fellowship programs deprive general surgery residents of the opportunity to perform many of the operations in the given subspecialty which they are quite capable to perform. We have now demonstrated that is, indeed, the case with both vascular surgery and pediatric surgery fellowships.[54,55] As a result of both their obligation to the fellows and their understandable desire to work with individuals who have shared interests and are more mature in their training, attending surgeons practicing the given subspecialty devote less time and attention to the teaching and evaluation of the general surgery residents. Another obstacle to general surgery residency resulting from the proliferation of subspecialty fellowship training is that more and more faculty members have had such subspecialty training and largely or entirely practice in that subspecialty with the end result being fewer and fewer truly *general* surgeon role models on the faculty of the general surgery residency program.

Arguably the greatest challenge to general surgery residency education today is a lack of appropriate resident supervision.[56] That is certainly not to say that general surgery residents are not supervised. Virtually every action of junior residents is directly supervised by an attending surgeon, a more senior resident, or a highly experienced physician extender. Such supervision is highly appropriate for the very junior resident. Appropriate supervision, though, also entails allowance for senior residents to exercise their ability to make diagnoses, formulate and execute patient care plans, perform operations, and even to make some mistakes without moment-to-moment input from the attending surgeon so long as safe patient care is rendered. There are several easily identifiable reasons why attending surgeons may excessively supervise senior residents. Attending surgeons have ever-increasing productivity demands. It takes more time to allow the resident to formulate a plan, explain the plan to the attending and for the attending to give feedback on the plan than it does for the attending to simply tell the resident what to do.

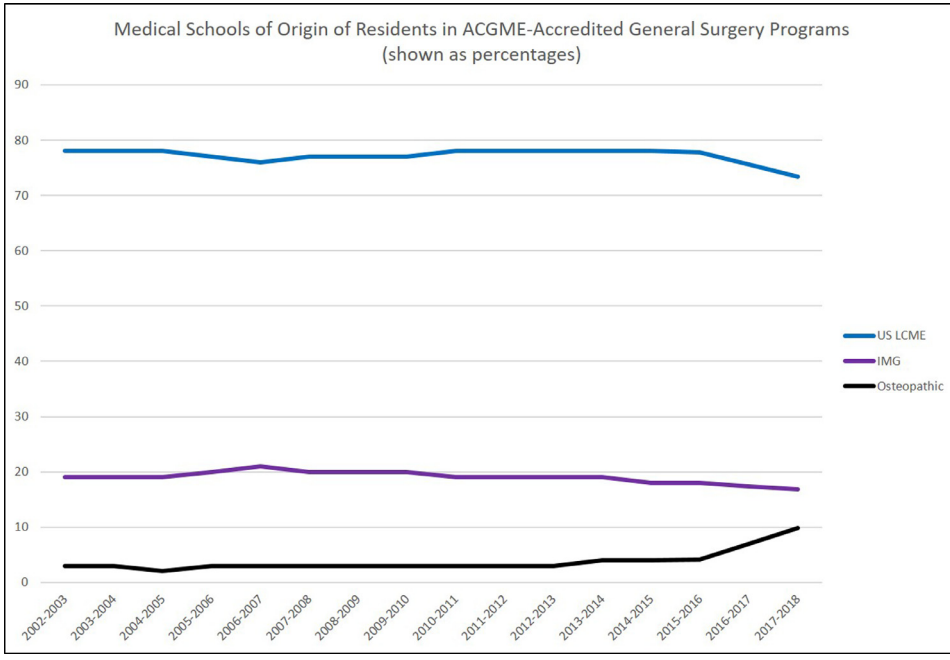

Fig. 6. Medical schools of origin of residents in Accreditation Council for Graduate Medical Education-accredited general surgery programs (shown as percentages).[37] The percentage of U.S. allopathic medical school graduates has not changed significantly since 2002. The proportion of international medical graduates (IMG) has decreased from its peak of 21% in 2006-2007 to 16.8% in 2016-2017. ($P < 0.01$) Largely due to the transition to a single GME accreditation system, the percentage of residents in ACGME-accredited surgery programs who graduated from osteopathic medical schools has more than trebled since 2013-2014. ($P < 0.01$) Graduates of Canadian and "other" medical schools have not approached 1% of surgery residents at any point in the last 15 years.

The attending surgeon may also have concerns about quality metrics, hospital policy, medical-legal issues, and criteria for billing. It is also quite possible that the attending surgeon, herself or himself, was not appropriately supervised as a senior surgeon and either does not know how to give the resident latitude or lacks the confidence to do so. Nevertheless, without appropriate supervision the skills, judgment, and confidence of residents cannot be properly evaluated and certainly cannot mature to the level necessary for independent practice.

The future of general surgery residency education

Duration of residency

Although there have been some intermittent changes in the requirements for the way that the time is structured, the minimum required duration of general surgery residency has been 5 years for several decades. Despite there now being more knowledge to learn and more techniques to master than ever before, it seems highly unlikely that general surgery residency will ever be required to extend beyond 5 years. One major obstacle to doing so would be funding. More than 1200 individuals complete general surgery residency each year and there is simply no readily identifiable source of funds to pay 1200 more residents each year if the requisite period of residency were extended to 6 years or, certainly, to pay 2400 more residents each year if the requisite period of residency were extended to 7 years. Indeed, although the rationale for doing so in the face of growth in general surgical knowledge and techniques certainly challenges logic,

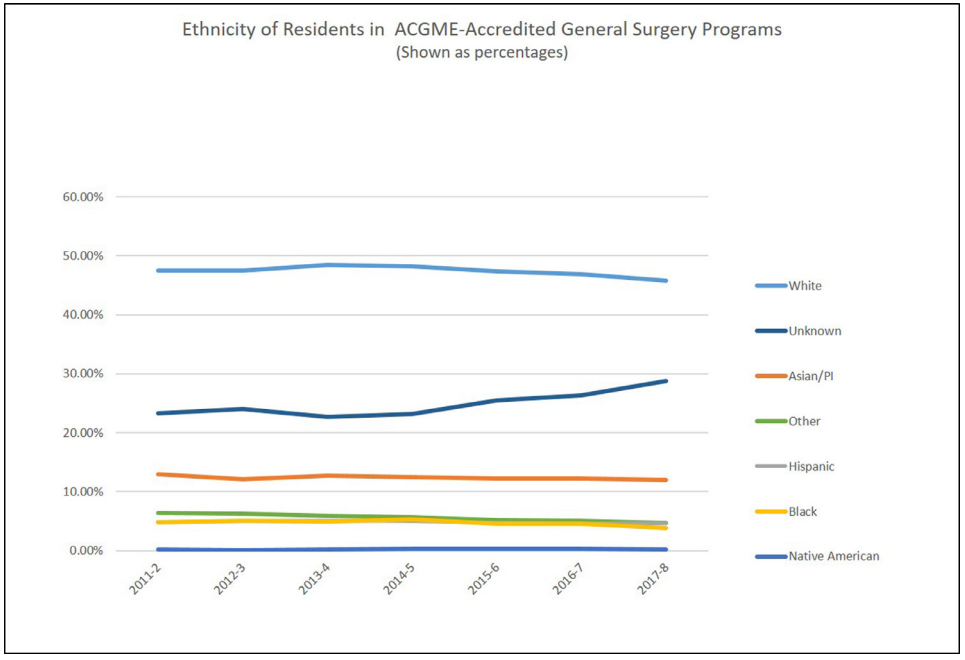

Fig. 7. Self-reported ethnicity of residents in Accreditation Council for Graduate Medical Education-accredited general surgery programs (shown as percentages).[37] These data have been collected by the ACGME only since the 2011-2012 year. The increase in the "Unknown" category is statistically significant. ($P < 0.05$) The decrease in the "Other" category is also statistically significant. ($P < 0.001$) Note that the percentages of Hispanic, Black, and "Other" very closely approximate one another, resulting in a high degree of overlap in this graph.

recent developments have actually shortened general surgery residency for a limited number of individuals. The Early Specialization Program allows residents pursuing advanced training in vascular surgery to essentially count 1 year of training toward both general surgery residency and vascular surgery fellowship, with the option of gaining ABS certification in both.[57] The Joint Surgery/Thoracic Surgery Program similarly counts 1 year toward both general surgery residency and thoracic surgery fellowship, with the option of certification by both the ABS and the American Board of Thoracic Surgery.[58] One restriction that has limited the number of individuals pursuing either of these programs is that all of the training (residency and fellowship) must occur in a single institution. Another manner in which general surgery residency can effectively be shortened by 1 year is the Flexibility in Training option.[59] In this paradigm, a resident can spend up to 12 months during the PGY-4 and PGY-5 years in a derivative subspecialty of general surgery. The chosen subspecialty may be, but does not necessarily have to be, a subspecialty in which ACGME-accredited programs exist. It is not required that the individuals pursuing Flexibility in Training go on to formal fellowship training in the chosen subspecialty. If the individual does go on to formal fellowship training in the subspecialty, he/she would enter that fellowship much better prepared but is not allowed to shorten the time in fellowship, at least in ACGME-accredited programs. Individuals pursuing the Flexibility in Training option must meet all of the usual qualifications to enter the ABS certification process including minimum case numbers and a full 12 months of chief residency experience. The extent to which these paradigms will be utilized going forward or other paradigms by which general surgery residency can be foreshortened will be developed remains to be seen.

Traditionally, completion of general surgery residency was a prerequisite for training in any of the derivative subspecialties of general surgery and for most it remains a prerequisite. However, in addition to traditional fellowship programs, plastic surgery, vascular surgery, and thoracic

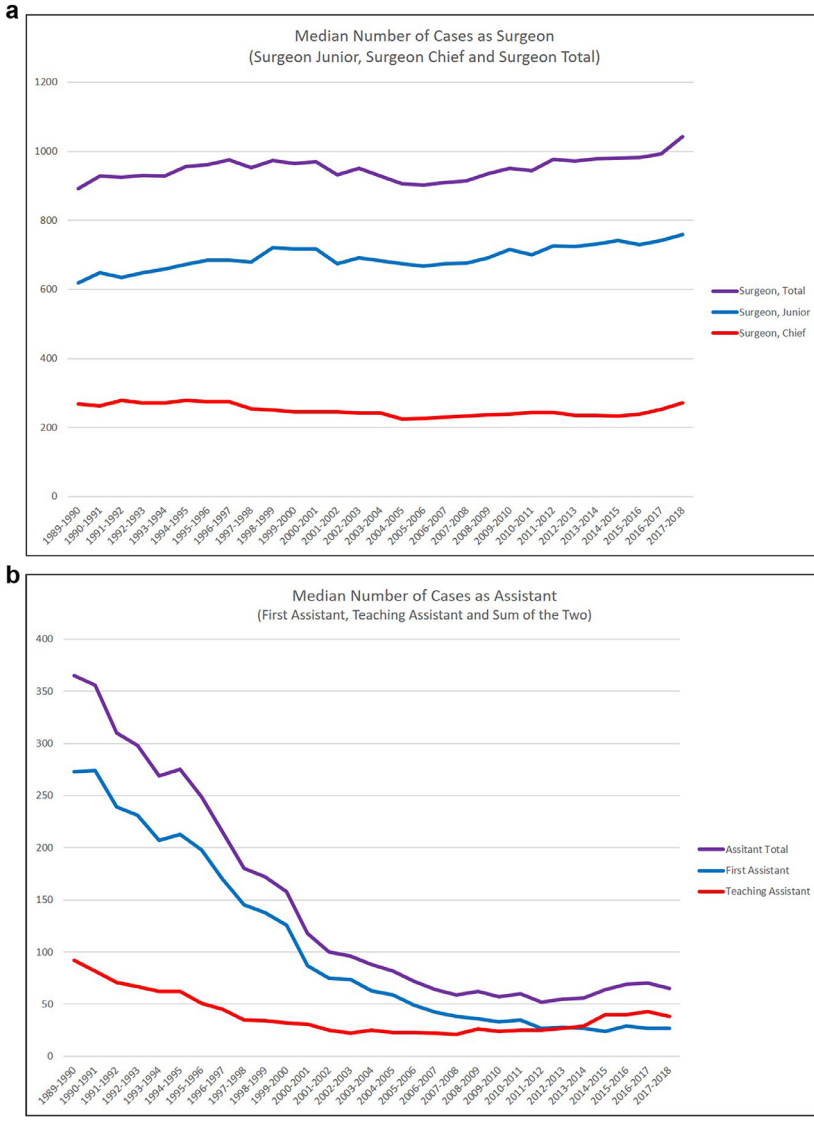

Fig. 8. (a) Median number of cases as surgeon - surgeon junior, surgeon chief and surgeon total (sum of surgeon junior and surgeon Chief).[23] The median number of cases as surgeon chief has declined significantly since 1989 ($P < 0.001$). However, because of the significant increase in the number of Surgeon Junior cases ($P < 0.001$), the surgeon total case number has increased significantly ($P < 0.05$).
(b) Median number of cases as assistant—first assistant, teaching assistant and assistant total (sum of first assistant and teaching assistant).[23] Coincident with (and likely as a result of) the announcement in 2013 that individuals completing residency in 2015 and beyond must act as teaching assistant in a minimum of 25 cases, there has recently been an increase in the median number of teaching assistant cases. Nevertheless, the declines in the numbers of both first assistant cases and teaching assistant cases since 1989 are highly significant ($P < 0.0001$).
(c) Total operative experience representing the sum of the national median numbers of surgeon total cases (surgeon junior plus surgeon chief) and assistant total cases (first assistant plus teaching assistant).[23] The increase in surgeon junior cases has resulted in an increase in the surgeon total cases (see Fig 8a). However, given the substantial and highly significant decline in the total number of assistant cases (see Fig 8b), there has been a significant decrease in the total operative experience of general surgery residents ($P < 0.0001$).

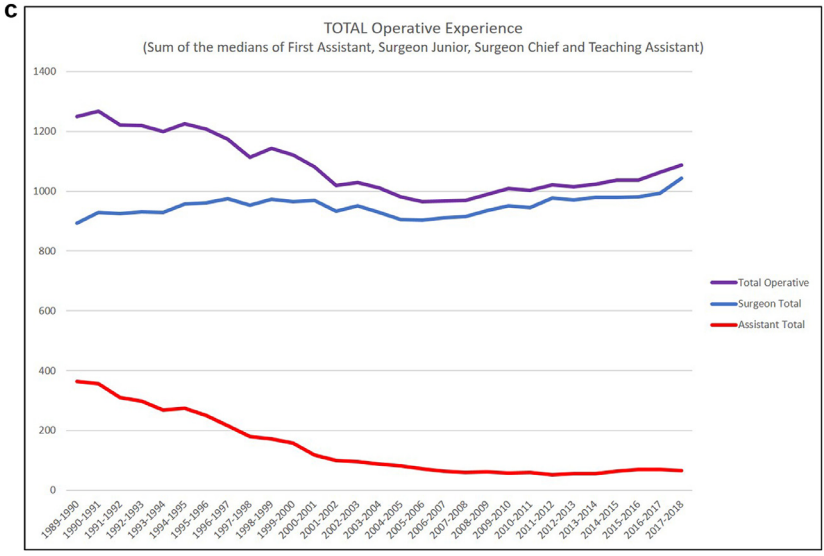

Fig. 8. Continued

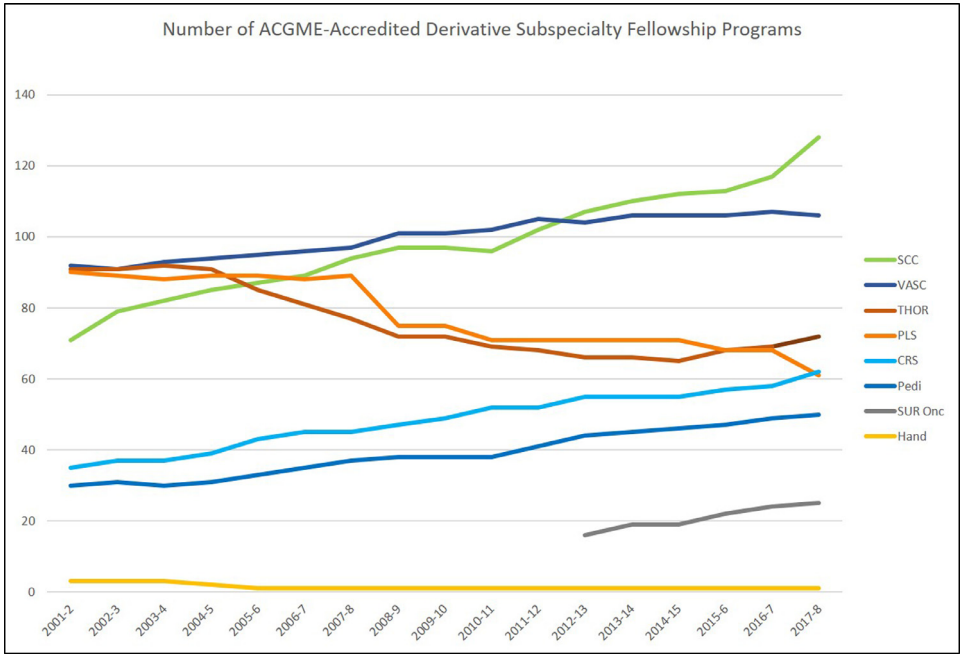

Fig. 9. Number of Accreditation Council for Graduate Medical Education-accredited derivative subspecialty fellowship programs.[37] Significant decreases in the number of plastic surgery (PLS) programs and thoracic surgery (THOR) programs have been offset by significant increases in the number of surgical critical care (SCC), vascular surgery (VASC), colon and rectal surgery (CRS), and pediatric surgery (Pedi) programs as well as the addition of complex general surgical oncology (Surg Onc) programs, such that the total number of ACGME-accredited programs in subspecialties derivative to general surgery has increased significantly.

Table 2
Fellowships in derivative subspecialties of general surgery.

ACGME-Accredited
Colon and rectal surgery
Complex general surgical oncology
Hand surgery
Pediatric surgery
Plastic surgery
Surgical critical care
Thoracic surgery
Vascular surgery
Accredited by other organizations
The Fellowship Council
Advanced colon and rectal surgery
Advanced gastrointestinal surgery
Advanced thoracic surgery
Bariatric surgery
Flexible endoscopy
Hepato-pancreatic-biliary surgery
Minimally invasive surgery
Society for surgical oncology
Breast oncology
American Association of Endocrine Surgeons
Endocrine surgery
American Society of Transplant Surgeons
Kidney
Liver
Pancreas
(and various combinations of the above)

surgery now have “integrated” programs which can be entered directly from medical school.[60-62] The minimum amount of general surgery training deemed necessary for the practice of the subspecialty is “integrated” into the residency in what was traditionally considered to be the derivative subspecialty.

The growth in the number of ACGME-accredited programs in subspecialties derivative to general surgery since 2001-2002 has been steady and statistically significant despite substantial declines in the number of plastic surgery and thoracic surgery fellowship programs (presumably as a result of the establishment of integrated programs)[37] (Fig. 9). To the more than 500 fellowship programs accredited by ACGME in 2017-2018 must be added the more than 280 derivative subspecialty programs accredited by other organizations[63-67] (Table 2). In 2017-2018 there were 1308 individuals enrolled in the ACGME-accredited derivative subspecialty programs[37] (Fig. 10). Of those, 750 were first year fellows. The number of first year fellows in ACGME-accredited general surgery derivative subspecialty programs has increased significantly over the past decade. The significant decrease in the number of first year fellows in plastic surgery has been more than offset by significant increases in the number of first year fellows in colorectal surgery and surgical critical care and the establishment of programs in complex general surgical oncology (Fig. 11). It is not required to have completed general surgery residency in order to enter a surgical critical care fellowship program. Individuals can enter surgical critical care fellowship programs after completion of only 3 years of residency in anesthesiology, emergency medicine, or any of 8 surgical specialties. For this and other reasons, the fact that there were 750 first year fellows in ACGME-accredited subspecialty programs in 2017-2018 does *not* mean that 750 of the 1211 individuals who completed an ACGME general surgery program in 2016-2017 entered an ACGME-accredited fellowship program. Non-ACGME-accredited fellowship programs have well over 200 first year fellowship positions.[63-67] Although the vast majority of those positions are filled by individuals who have completed a general surgery residency program, those programs may or may not have been in the United States and ACGME-accredited. The upshot of all of this is that there are an increasing number of fellowship programs available in

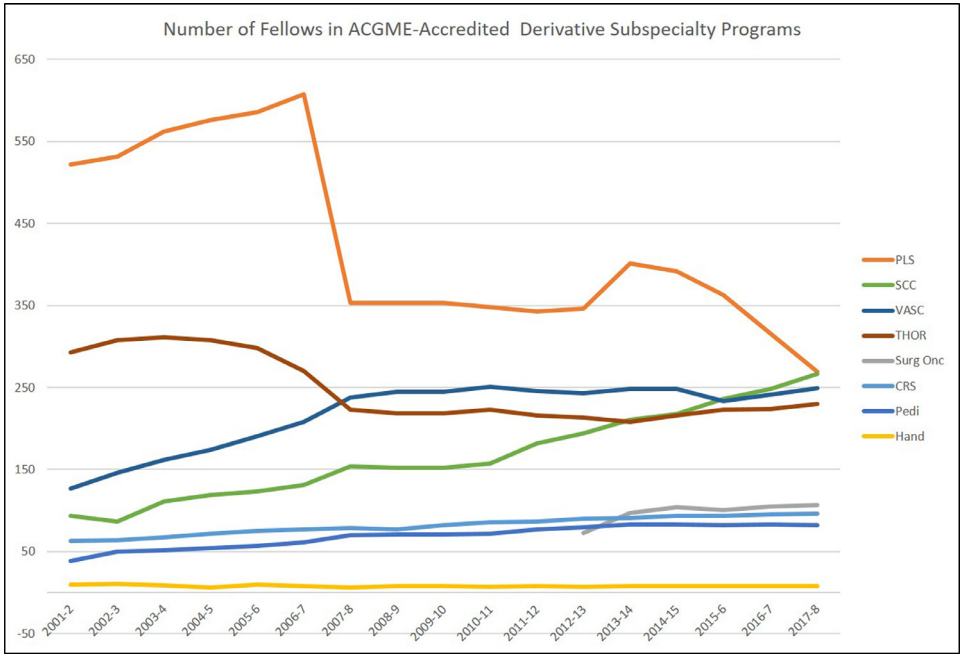

Fig. 10. Number of fellows in Accreditation Council for Graduate Medical Education-accredited derivative subspecialty programs.[37] Significant decreases have occurred in plastic surgery (PLS) and thoracic surgery (THOR) presumably as a result of a transition to integrated programs in those disciplines. These are offset by significant increases in the number of fellows in surgical critical Care (SCC), vascular surgery (VASC), colon and rectal surgery (CRS), pediatric surgery (Pedi), and the addition of complex general surgical oncology fellows (Surg Onc), leading to an overall increase in the number of fellows in the fellowship programs.

subspecialties derivative to general surgery and there are an increasing number of fellows in those programs. Most of those positions are occupied by individuals who have completed an ACGME-accredited general surgery program, but the exact number of such individuals in those positions is not known. Therefore, we do not know exactly what percentage of individuals who complete an ACGME-accredited general surgery residency actually enter subspecialty training. That number has been estimated to be 80% and steadily increasing.[68] Therefore, although the total time complete general surgery residency has not increased in decades, the average amount of total amount of time that individuals who complete general surgery residency spend in formal training most certainly has increased.

Duty hour limitations

It has now been almost 15 years since duty hour limitations became a reality in every ACGME-accredited residency and fellowship program. Although some other specific duty hour regulations have been and probably will be added, deleted, or modified along the way, the limitation of 80 hours per week (averaged over 4 weeks) has remained in place throughout those 15 years and will remain in place for the foreseeable future.

The residents

Given that there has been essentially no change in the average age of first year surgery residents in the last decade it is unlikely that this will change going forward unless there are substantial changes in the prerequisites for entry into medical school or the duration of

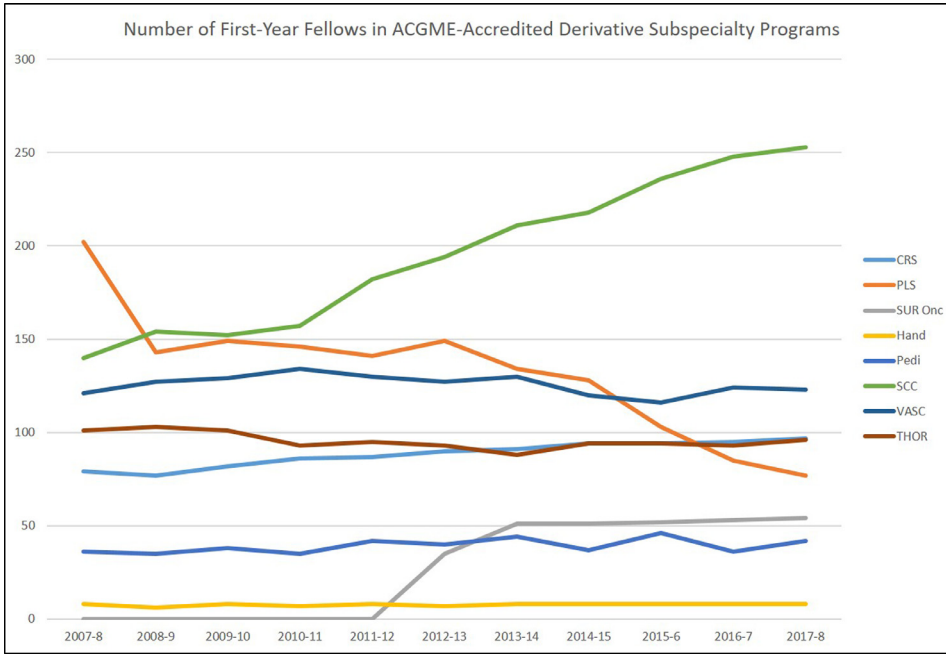

Fig. 11. Number of first year fellows in Accreditation Council for Graduate Medical Education-accredited derivative subspecialty programs.[37] The significant decrease in the number of first year fellows in plastic surgery (PLS) has been more than offset by significant increases in the number of first year fellows in colorectal surgery (CRS) and surgical critical care (SCC) and the establishment of programs in complex general surgical oncology (Surg Onc). Pedi, pediatric surgery; THOR, thoracic surgery; VASC, vascular surgery.

undergraduate medical education. Similarly, it appears unlikely that there will be any significant change in the near future with respect to the race/ethnicity of surgery residents. There has been no substantial change in the race/ethnicity of general surgery residents over 7 years that this has been tracked[37] (Fig. 7). Furthermore, among US medical school graduates, the proportions of Native American/Alaskan, Black, Hispanic, and Asian graduates have remained fairly stable. A decline in the proportion of White graduates appears to be largely due to a growing number of individuals reporting "Multiple" ethnicity as well as by graduates who report "other" ethnicity or who are non-US students[69,70] (Fig. 12). One change in that seems very likely to continue is the growing percentage of female surgery residents. Due to the transition to the single GME accreditation system, an absolutely predictable change is continued growth in the proportion of residents in ACGME-accredited surgery programs who graduated from osteopathic medical schools. As noted, this change is already underway (Fig. 6). Certainly, the proportion of osteopathic graduates in ACGME surgery programs will continue to rise until the transition is complete in 2020. Whether it will continue to rise after that remains to be seen.

The programs

The number of ACGME-accredited general surgery programs and the number of residents in those programs will continue to increase until at least 2020 when the transition to a single GME accreditation system is complete. Thereafter, the number of programs will likely fluctuate as it has historically due to the creation of a few new programs, mergers of some programs, and closure of a very few programs. History indicates that the net change in the number of programs after 2020 will likely be a slight increase. History also indicates that there will be a slow but

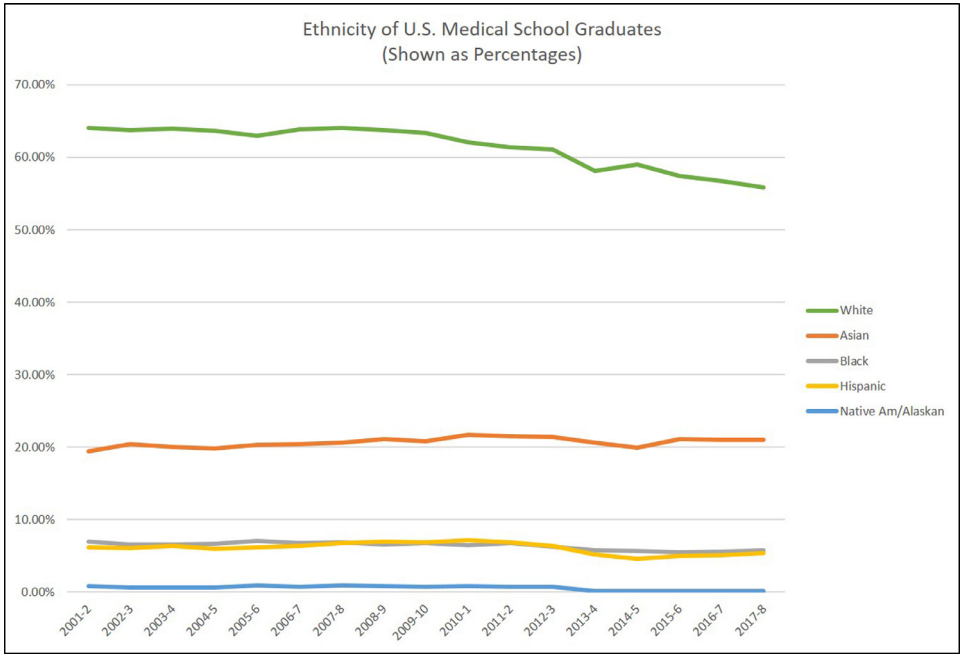

Fig. 12. Ethnicity of U.S. medical school graduates shown as percentages 2001-2002 through 2017-2018. [69,70] During this period, proportionate representation has remained fairly steady for Native American/Alaskans (less than 1%), Blacks (5.5%-7%), Hispanics (5%-7.1%), and Asians (19.4%-21.7%). The decrease in the proportion of White graduates is largely influenced by a growing number of individuals reporting "multiple" ethnicity as well as by graduates who report "other" ethnicity or who are non-US students.

steady increase in the number of general surgery residents beyond the year 2020. The mean number of clinical sites used by general surgery programs has steadily increased and, for better or worse, that trend will likely continue. The number of residents per program reached its zenith in 2013-2014 academic year at 30.39. As previously noted, the smaller average size of the previously AOA accredited programs has led to a decline in the mean program size as those programs have gained ACGME accreditation. One would anticipate that decline to continue through the year 2020 and the termination of the transition to a single GME accreditation system before beginning to slowly creep back up. Finally, given recent trends it seems highly likely that the number of faculty members per program will continue to increase and that the tenure of program directors will continue to decrease.

Operative case logs

The Review Committee for Surgery will continue to utilize case logs in the process of program accreditation. And, as has occurred since case logs became a part of the accreditation process, there will be periodic adjustments in the numbers of cases required in total and in practice patterns. As currently configured, the case log system simply counts cases as self-reported by residents. In the foreseeable future, it is quite possible that the case log system could be linked to—or even include—mechanisms for evaluating the resident in technical performance in the operating room, preparation for a particular operation, and perioperative care as well as for tracking patient outcomes. It is important to emphasize that the Review Committee for Surgery utilizes case logs only for the purpose of determining whether a program offers sufficient breadth and depth of operative experience appropriate for resident education. It is not

a certifying body and, therefore, does not and will not concern itself with the performance of individual residents. However, the performance of individual residents is of the utmost concern to programs and, ultimately, to the certifying boards. The hope would be that an evaluation system which is either a part of—or linked to—the case log system would facilitate and enhance the programs' ability to evaluate the performance of their residents. It is also possible that in the future the operative data for a program could be passively acquired from the electronic medical records system(s) utilized in the hospital(s) to which that program's residents rotate. Such a system would free the residents from having to manually enter operative data and may even provide more uniform recording of cases.

Derivative subspecialty training

It is conceivable that some major change or combination of changes in the practice patterns of individuals who have completed general surgery residency could result in the development of fewer derivative subspecialties (and sub-subspecialties), fewer fellowship programs in those disciplines, and decreased interest on the part of general surgery residents in pursuing further formal education in those areas. For example, such changes could come about as a result of major restructuring of payment for procedures, health care system consolidation resulting in diminished demand for previously competing subspecialists, development of nonsurgical treatments for diseases and conditions currently treated by surgeons, or the eradication of specific diseases and conditions which are currently treated surgically. For the foreseeable future, though, it appears likely that there will be more subspecialty fellowship programs in a growing number of increasingly specific areas which are pursued by progressively more individuals who have completed general surgery residency.

Simulation

Simulation will predictably play an increasingly important role in the education of surgery residents going forward. In part this will be due to demands of regulators such as the ABS, health system credentialing committees, and possibly the ACGME. Public expectations may well drive those demands. Beyond regulations, though, the value of simulation in the education of surgeons is increasingly appreciated, the variety of simulation tools is ever-increasing, and the relative dollar cost of those tools is decreasing. The challenge for surgery programs is now and will continue to be striking the appropriate balance of clinical experience, didactics, and simulation in the setting of duty hour limitations.

Telehealth

With technology that is increasingly sophisticated, reliable, and available at a relatively diminishing cost, telehealth will play a progressively more important role in surgery. Routine remote accomplishment of even very minor surgical procedures is at least decades away and may never come to fruition. Nevertheless, surgical care in the form of routine postoperative follow-up "visits," surgical consultation, and even preoperative "visits" will become increasingly common. Such care will benefit patients, referring physicians, and surgeons in terms of convenience and efficiency and will, to some degree, bring surgical care to areas where there are no surgeons. Surgical residents will predictably participate in telehealth to an increasing degree. For that reason, it is likely that curricula and even program requirements centered on the provision of telehealth will emerge in the near future.

Competency-based resident education

Competency-based medical education has been defined as "an approach to and philosophy of designing the explicit developmental progression of health care professionals to meet the needs of those they serve. Among its fundamental characteristics is a shift in emphasis away from time-based programs based solely on exposure to experiences such as clinical rotations in favor of an emphasis on needs-based graduate outcomes, authenticity, and learner-centeredness."[71] The concept of competency based resident education (CBRE) is that residents graduate from a program and are extended the privilege of unsupervised clinical practice once they have demonstrated sufficient competence in the necessary elements of the specialty rather than on the basis of having completed a prescribed length of time in the residency program.[72] Competency-based medical education and, by extension, CBRE, have enjoyed numerous champions and wide support during the past decade. As appealing as the concept may be, there are numerous obstacles to the implementation of CBRE. Regulatory obstacles include the structure of Medicare funding of GME and current requirements by the ABS and ACGME that general surgery residency be 5 years in duration. Local barriers are more numerous and may be even more intransigent than the regulatory barriers. These include the design, implementation, and faithful utilization of an evaluation system that would monitor in real-time the progress of residents toward the numerous competencies they would be expected to demonstrate. This would require a great deal of faculty time (for which they reasonably expect compensation) and expertise (which would require substantial and ongoing faculty development in education). Allowing residents to progress at different rates through the requisite clinical experiences would disrupt any planned rotation schedule, thus leaving some clinical services without residents from time to time. In short, most programs would have to undergo major structural and cultural change to successfully implement a competency-based residency system. Perhaps the greatest obstacle to competency-based resident education is that there is currently no consensus on what a general surgeon is and certainly no consensus on what specific competencies a general surgeon should learn, be able to demonstrate, and maintain.

The ACGME has very gently nudged programs toward competency-based education for more than a decade. The 2 most notable steps in that direction have been enunciation of "the competencies" in the Common Program Requirements which became effective in 2004[31] and the 2015 requirement that each program report Milestone evaluations on each resident semiannually to the ACGME.[73] Still, there are no competency-based general surgery residency programs in the United States. Indeed, the only program in the world which has implemented, employed, and reported its results with competency-based resident education is the orthopedic surgery program of the University of Toronto.[74]

The movement toward competency-based residency education will predictably continue. When—even whether—truly competency-based residency education ever becomes a reality in American general surgery programs remains to be seen.

Conclusions

General surgery residency education began with William Stewart Halsted at The Johns Hopkins Hospital in 1889. It has been shaped by the AMA, the ACS, The ABS, oversight bodies including the Conference Committee on Graduate Training in Surgery, the LCGME, the original ACGME, the current ACGME and its Review Committee for Surgery, and by the often forgotten innovations of numerous individuals. For several decades, general surgery residency has entailed 5 years of clinical training and this will be the case for the foreseeable future. The number of general surgery residency programs has waxed and waned over time but the number of general surgery residents has continued to slowly increase. The average size of programs in terms of the number of residents, the number of faculty members, and the number of clinical sites steadily grew until the very recent migration of programs from AOA accreditation to ACGME accreditation. After a new baseline of program size is reached at the conclusion of that migration, there

is every reason to believe that average size of programs will again begin to slowly increase. The only notable objective changes in the residents have been the slow but steady increase in the percentage of women and a recent trebling of the percentage of residents who graduated from osteopathic medical schools. The former will predictably continue into the future. The latter will predictably stabilize in or shortly after the year 2020.

Demonstration of the provision of an adequate volume and variety of operative cases to the residents is necessary for program accreditation. This will be true into the future although the requirements for both the volumes and the varieties will predictably change over time as the specialty of general surgery continues to evolve. Evaluations of individual resident technical ability/competence will predictably become increasingly important to both the programs and to the certifying boards. It is certainly conceivable that the ACGME will act as a partner in facilitating the collection of those evaluations, but it will not utilize evaluations of individual resident technical ability/competence in the accreditation process.

The number and variety of derivative subspecialty and sub-subspecialty programs will predictably continue to increase into the foreseeable future as will the number of general surgery residency graduates who pursue additional training in those disciplines. Simulation training will be increasingly formalized and utilized in general surgery residency education but will never achieve primacy over clinical experience. In response to its increasing role in clinical care, curricula and requirements regarding telehealth in surgery will emerge to the benefit of both patients and surgeons. Finally, movement toward competency-based education in general surgery residency will continue, but it is doubtful whether true CBRE will ever become the standard of education in general surgery.

In 1904, William Stewart Halsted said, “We need a system, and we will surely have it, which will produce not only surgeons but surgeons of the highest type, men who will stimulate the first youths of our country to study surgery and to devote their energies and their lives to raising the standard of surgical science.”[75] Dr. Halsted would probably not be surprised to learn that more than a century after he made that statement many such systems have evolved, that they continue to evolve, and will continue to evolve.

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