

History and Evolution of Anesthesia Education in United States

Mian Ahmad* and Rayhan Tariq

Department of Anesthesiology and Perioperative Medicine, Drexel University College of Medicine, Philadelphia, PA, USA

*Corresponding author: Mian Ahmad MD, Vice-Chair Education, Department of Anesthesiology and Perioperative Medicine, Drexel University College of Medicine, 245 N. 15th Street, MS 310, Philadelphia, PA 19102, USA, Tel: 215-762-8936; Fax: 215-762-8656; E-mail: mian.ahmad@drexelmed.edu

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Abstract

Resident education is both, a science and an art. Quality and homogeneity of resident education has a considerable correlation with patient safety. This article appraises how formal training in anesthesiology was started in United States and how it has evolved over the years. A comprehensive literature search was performed to identify journal articles, periodicals and historic documents that detailed the development and progression of academic anesthesiology. Various Anesthesiology Departments were also consulted. In 1927 Dr. Waters established the first ever academic department of Anesthesiology at the University of Wisconsin, Madison. The graduates from that residency programs, the so called "Aqualumni" went on to establish residency programs throughout the country. In 1938 American Board of Anesthesiology was formed, elevating the level of anesthesiology to a distinct specialty. World War II and post war era was a period of rapid growth in anesthesiology in general and academic anesthesiology in particular. In late 1970's and early 80's American College of Graduate Medical Education (ACGME) closely regulated the anesthesiology residency programs by recommending minimum program requirements. Over the years the training model has transformed from a relatively heterogeneous one to a uniform outcome based model with focus on learning and teaching of 6 core competencies. This article explores how the anesthesiology education evolved throughout 20th century to its present form.

Keywords: Academic; Education; Residency; Internship; Anesthesiology history; Training; ABA; ACGME

Introduction

Today residency is considered to be the essential dimension that ensures the transformation of a graduating medical student into an independently practicing physician. The training model was not as clear in early days of medical education. Medicine had utilized the same apprentice based model that other trades were using to train the artisan of the next generation. An interested individual would get attached to a practicing physician, observe him dealing with patients and over time learn the knowledge and skills which enabled him to diagnose and treat conditions that patients presented with. Very slowly this model evolved into a structured and process based training. Anesthesia training however, never really followed that pattern. Initially, surgeons administered anesthetics to their patients and then directed nurses to do the same. Physicians interested in this branch of medicine had to teach themselves and soon felt the need to improve upon the technical and cerebral part of anesthetic administration.

This article is meant to review the differences between these early anesthetists and the physicians certified by American Board of Anesthesiology to be the anesthesiologists practicing this specialty of medicine today. Even more importantly, it is going to examine the content and structure of education as it has evolved overtime.

The Early Years: 1900-1920

Surgery has existed long before anesthesiology, but before anesthesia, surgery was a means of last resort. The notion of undergoing surgery was so painful that many would prefer to allow a disease to run its natural course than going under the knife. The

greatest development in history of medicine no doubt is the ability to alleviate pain during surgery and essentially making modern surgical practice possible. Although the first public demonstration of General Anesthesia was in 1846 by a dentist at Massachusetts General Hospital, the growth of anesthesiology as a specialty was slow [1]. For most of the early 20th century Anesthesiology remained a neglected field because of the general perception that very little training was needed to administer anesthetics.

During most of the early part of the 20th century instructions in anesthesia were nonexistent and the specialty was being practiced only by a few self-taught individuals [2]. Among them was James T. Gwathmey who authored the first authoritative text on the subject in 1914. His book "Anesthesia" would remain a valuable educational resource over the next few decades [3]. He was the first president of the American Society of Anesthetists, later renamed American Society of Anesthesiologists (ASA) [4]. He, along with other regional anesthesiology societies emphasized the need to give organized instructions and training in Anesthesia.

In 1924, McMechan started the first journal in the specialty; Anesthesia and Analgesia [5]. Previously American Journal of Surgery used to publish quarterly supplements on anesthesia and analgesia. In 1940 Henry Ruth started Anesthesiology, the official journal of ASA. During these early years there was a gradual movement towards establishment of Anesthesia as distinct medical specialty that should be practiced by physicians. History of Anesthesiology residency training was interlinked with the push for specialty status for Anesthesiology in the late 1920's and 1930's.

A Transition from Nurse Anesthetists to Trained Physician Anesthetist

During the latter part of 19th century and the early part of 20th century anesthesia, usually in the form of ether, was mostly administered by surgical nurse or a medical student/intern. Fortunately the surgical procedures at that time were neither as lengthy nor as complicated so these practices seen as rather safe. However with the evolution of surgical techniques and introduction of new techniques in anesthesia including the use of breathing tube in trachea by Ivan McGill and the introduction of Neuraxial Blocks by James Corning, it was becoming apparent that anesthesiology was a specialty of its own and hence needed physicians that were specially trained to optimally deliver anesthesia [6]. Dr. Isabella Herb, chief anesthetist at Rush University was one of the first individuals with an academic appointment in Anesthesiology. She advocated *"nurses when properly trained make very good anesthetizers but that their lack of medical training prevented them from being able to choose a particular anesthetic technique that would best suit the patient's and surgeon's needs* [7]. *Also nurses' minimal training in medicine and lack of training in research meant that they were not suited to carrying out research in anesthesia."*

Another contributing factor for this shift was the push from national and local Anesthesiology Societies. Gatch and other early ASA leaders emphasized the need to establish a standardized approach to train interns in Anesthesia [8].

Contributions of Dr. Isabella Herb

There was no formal training for anesthesia as a student or at post-graduate level. What little training was there was mostly through apprenticeship. At that time anesthesia training was essentially a short course of few weeks in which anesthetics agents and equipment was taught entirely in the OR. The physicians were being taught as technicians [9].

Wanting to rectify that while at Rush, Dr. Herb Developed a curriculum for teaching medical students comprised of pharmacology, physiology of Anesthesiology and selection of anesthetics [10]. Dr. Herb believed that this program was to be delivered by a physician who had expertise and training in delivery of anesthetics in that hospital, and not by surgeons [11]. She wrote, *"Unfortunately most anesthetists receive their meager instruction from surgeons during the operations, and it is a notorious fact that the majority of surgeons are poor anesthetists. From the fact that a man operates hundreds of times a year, it does not follow that he is proficient in the art of producing and maintaining anesthesia"* [7].

Although the curriculum was only for medical students and this was not a postgraduate training but it was first of its kind and it set course for further development of education in anesthesia.

Dr. Waters and the First Academic Residency Program in Anesthesiology

In 1927 Dr. Waters established the first ever academic residency program of Anesthesiology in University of Wisconsin, Madison. While Dr. Waters' division of anesthesia at the University of Wisconsin remained a section under the department of surgery until 1952, it truly was the foremost beacon of anesthesia education [12]. The graduates from this residency program who called themselves as the 'Aqualumini'

went on to establish residency programs all over the United States. Dr. Waters focused on education and research along with providing optimum patient care. He inculcated morbidity and mortality analysis and discussion (M&M) and literature review in the residency didactics. He hoped to train physicians in the art and science of anesthesia who would go on to train other physicians in the safe clinical practice of anesthesia [2].

The Aqualumini

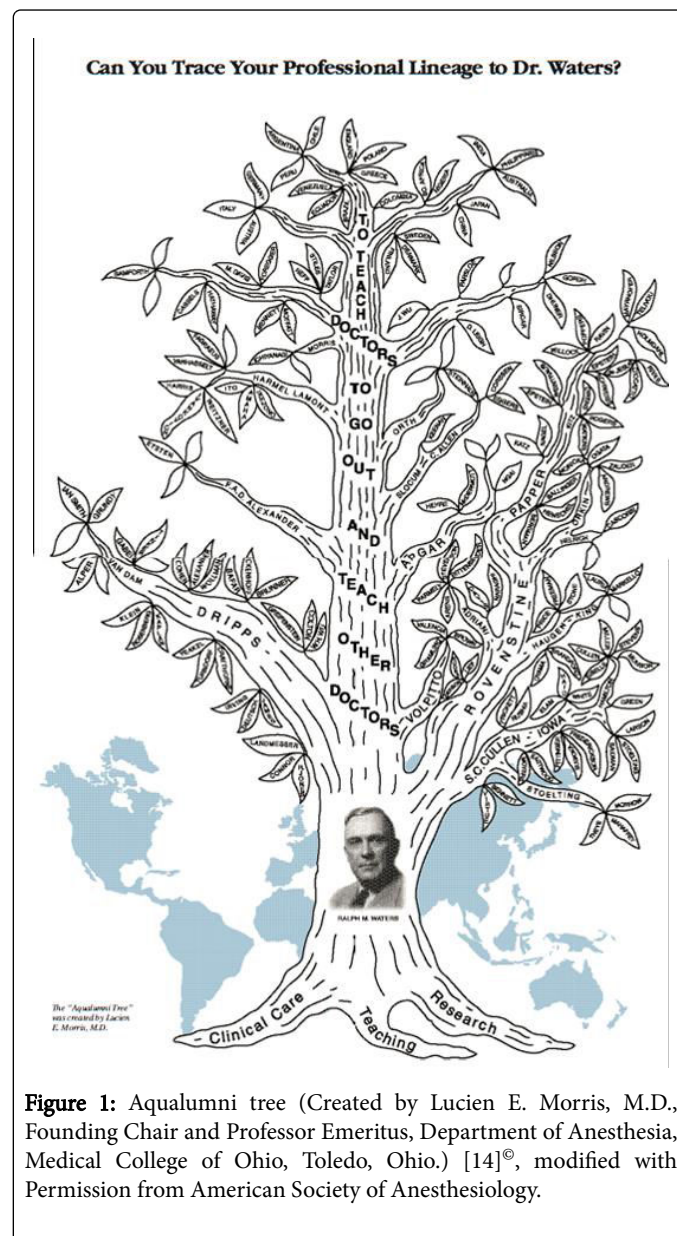


Figure 1: Aqualumini tree (Created by Lucien E. Morris, M.D., Founding Chair and Professor Emeritus, Department of Anesthesia, Medical College of Ohio, Toledo, Ohio.) [14]®, modified with Permission from American Society of Anesthesiology.

Individuals were attracted to anesthesiology from other specialties such as medicine, surgery and pharmacology. Among them is Emery Rovenstine who was Dr. Waters first and most distinguished disciple, he established the anesthesiology residency program at Bellevue/New York University (Figure 1). Among Rosenstein's notable residents were Stuart Cullen, Emanuel Papper, Virginia Apgar, Perry Volpitta, John Adriani, Louis Orkin, Sam Denson, Richard Ament, Gertie Marx, Martin Helrich, Sara Joffe, and Lewis Wright [13]. A genealogical

review estimates that more than 80 departmental chairs out of the 120 Medical Schools in US have been of Waters' lineage (Table 1) [14].



Figure 2: Aqualumni 1938 ©Mount Holyoke College. Archives and Special Collections, Virginia Apgar Papers (MS 0504).

| Year Residency Program was Started | Institution/University | The First Chairman of the Department |
|------------------------------------|---|--------------------------------------|
| 1927 | University of Wisconsin, Madison | Ralph Waters [2] |
| 1929 ^a | Hahnemann Medical College (now Drexel University College of Medicine) | Henry Swartley Ruth |
| 1930 [12] | University of Oklahoma | John Alfred Moffitt |
| 1935 [17] | | |
| 1935 | New York University/Bellevue Hospital | Emery Rovenstine |
| 1938 ^b | University of Buffalo | John Evans |
| 1939 | Medical College of Georgia | Perry P. Volpitto [16,18] |
| 1941 ^c | UCSF | Stuart Cullen [19] |

| | | |
|-------------------|--|--------------------------|
| 1941 | Massachusetts General Hospital | Henry K. Beecher [20,21] |
| 1943 | University of Pennsylvania | Robert Dunning Dripps |
| 1947 [22] | Ochsner Clinic Foundation, New Orleans, LA | George Grant |
| 1949 ^d | Columbia University | Emanuel Papper [2] |

Table 1: Some of the earliest anesthesiology residency programs. ^aFrom Drexel University website <http://drexel.edu/medicine/Academics/Residencies-and-Fellowships/Anesthesiology-Residency/>; ^bFrom University of Buffalo website - Department History -<http://www.smbs.buffalo.edu/anest/history.php> (retrieved 8/25/2015); ^cFrom UCSF website - About Us http://anesthesia.ucsf.edu/extranet/about_us/index.php (retrieved 8/25/2015); ^dThe Anesthesiology Service was first established as part of the Department of Surgery in 1937 under the direction of Dr. Virginia Apgar.

Dripps Started the Anesthesiology residency program at University of Pennsylvania; Cullen at UCSF; Emanuel Papper established the

anesthesiology department at Columbia University in 1949. Volpitto [15,16] established the first academic anesthesiology department in the south at medical college of Georgia, which he headed until 1972. The residency training program started slowly with the first resident in 1939 and the second one in 1941. From 1941-45, the majority of the male residents were recruited to a special wartime training program (Tables 1 and 2). John Lundy at Mayo Clinic started teaching anesthesiology as well as carrying out valuable research at that program. It was a chain reaction and soon enough residents graduating from above programs took the responsibility of propagating the knowledge of anesthesiology thorough out the country (Figures 2-4).



Figure 3: Dr. Volpitto teaching the Anesthesiology Residents®, modified with Permission from Department of Anesthesiology and Perioperative Medicine, Medical College of Georgia, Georgia Regents University.

| Year | Number of Residency Programs | Total number of Training Positions |
|-------------------|------------------------------|------------------------------------|
| 1927 | 1 | Data not available |
| 1943 | 45 | Data not available |
| 1948 | 214 | 487 |
| 1949 | 214 | 650 |
| 1964 | 296 | 1,858 (of which 1,145 were filled) |
| 1968 | 148 | 1,655 |
| 2010 | 132 | 5,556 |
| 2014 ^a | 133 | 5,686 |

Table 2: The growth of residency program with years [23,24]. ^aFrom FREIDA Specialty training statistics (retrieved 8/28/2015).

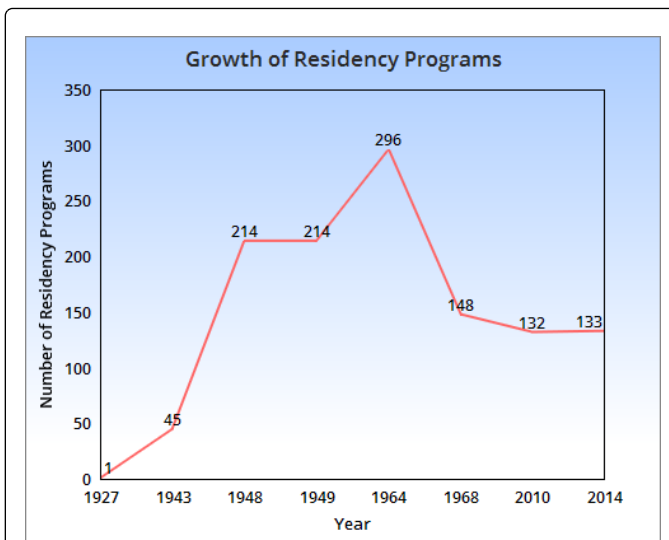


Figure 4: Growth of residency programs with year.

There was an increase in the number of residency programs after World War II which can be explained by the increased interest and increased demand for physician anesthesiologists.

The Influences of John Lundy

John Silas Lundy who is famed for the introduction of IV anesthetics in modern anesthetic practice [25] and the creation of first blood bank in the U.S. was the chair of anesthesia at Mayo Clinic from 1924-1959 [26,27]. Lundy’s contribution to anesthesia however is not just the scientific advancement of knowledge but also the promotion of anesthesiology education. In 1925, John Lundy established the first anatomy laboratory at the Mayo Clinic where he taught regional Anesthesia techniques to surgery trainees [28]. He is accredited with creating the Anesthetists’ Travel Club in 1929 in order to encourage flow of information between physicians practicing anesthesia. The participants, who were mostly in their thirties, discussed not only the clinical but also the basic research development relevant to anesthesiology. The Club met yearly till the start of World War II [29]. When the American Board of Anesthesiology (ABA) was formed in 1938 eight of the nine directors were members of the Travel Club. In 1941, in a large part due to his lobbying and political connections, the ABMS approved Anesthesia as a distinct specialty [30].

Development of ABA

It took more than a decade of meetings, conferences, and astute politics to convince public and professional organizations that this field merited specialty status. Finally an American Board of Anesthesiology (ABA) was formed as an affiliate of the American Board of Surgery (ABS) in 1937 and approved by American Board of Medical Specialties (ABMS) in 1938. The format of examination was changed to include MCQ within a decade and over time it was transformed to the current format. In 1941 it was approved as an independent primary Board (Table 3).

The First ABA Examination

The first “examining board in anesthesiology” was created in 1937 as a sub-board of the American Board of Surgery. The Board was composed of all the leaders of anesthesiology at that time (Table 5). The Examining Board established criteria for entering the examination process: [33].

1. Medical school graduation.

2. Completion of internship.
3. Two years of training, including 18 months of practical training in anesthesia.
4. Two years in the sole practice of anesthesia.
5. Membership in the AMA or a comparable approved national medical society.

| | |
|---------------------|---|
| President | Thomas Drysdale Buchanan ^a |
| Vice-President | Henry Ruth |
| Secretary-Treasurer | Paul Wood |
| Other Board Members | John Lundy, Emery Rovenstine, Harry Stewart, Ralph Tovell, Ralph Waters and Philip Wood-bridge. |

Table 3: The first ABA committee [31], ^aThomas Buchanan of the New York Medical Center-Bellevue Hospital was the recipient of ABA certificate number 1.

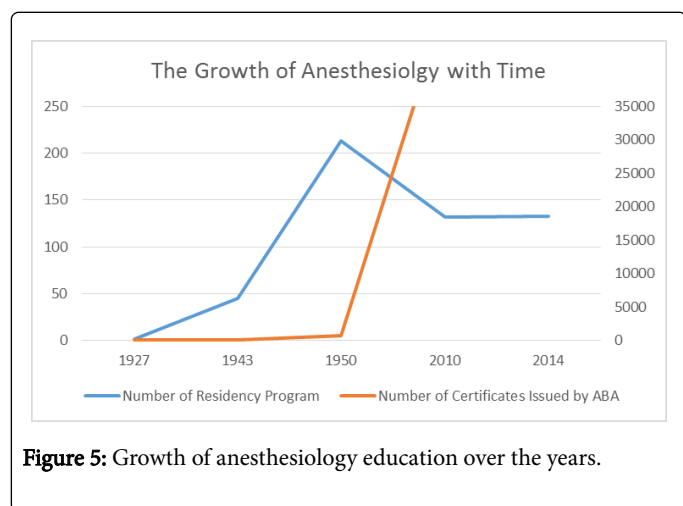


Figure 5: Growth of anesthesiology education over the years.

The process began slowly in the first year, when only 9 physicians were certified. Slowly gaining momentum, 272 anesthesiologists had been accredited by the end of World War II (Figure 5). Initially the Certificate was issued time indefinitely, but starting 2000 the candidates would be certified for a period of 10 years requiring re certification at the end of this period (Table 4).

| Year | Number of Cumulative Certificates Issued by ABA |
|------|---|
| 1939 | 9 |
| 1940 | 105 |
| 1950 | 706 |
| 1955 | 1,324 |
| 2015 | >50,000 |

Table 4: Total number of certificates awarded by ABA [24,32].

| | |
|-----------------|---|
| Founders | Professors and Associate Professors previously elected to Fellowship in the ASA were to be certified without examination. |
| Group A | Those having practiced for 15 or more years were to appear before the Board and could be certified without examination. |
| Group B | Those practicing for 7.5 years or more or having administered anesthesia in at least 1500 major procedures could be certified following only an oral examination. |
| Group C | Those who met the 5 “criteria for entering the examination process” listed above and submitted 150 of their cases for evaluation were allowed to enter the full examination system. |

Table 5: Categories for the first candidates for certification [33].

The Contribution of World War II to the Anesthesiology Education

World War II changed the course of American medicine significantly. The residency programs were depleted to meet the need of medical personnel of the U.S armed forces [9]. It was necessary to train more anesthetists (Medical anesthetists was the term used in early part of the 20th century for physicians whose primary responsibility was administration of anesthetics) to meet the war time need. A 12-week course was developed to train military physicians at academic institutions across the country. In addition, U.S. Surgeon

General mandated all Army officers to take a 2-week course in Surgery and anesthesia, formerly only required of medical officers [31]. Ralph Tovell [34] (Chair of Anesthesiology, Hartford Hospital), was given the task to overlook this Anesthesiology training. Medical Officers, the so-called “90 day wonders” were taught anesthesia in a 12-week course at leading anesthesia departments such as those at Bellevue Hospital, Mayo Clinic, Hahnemann Medical College, and the University of Wisconsin General Hospital [35]. Recommended textbooks included Beecher’s Physiology of Anesthesia (1938), Lundy’s Clinical Anesthesia (1942), Gillespie’s Endotracheal Anesthesia (1941), and Guedel’s Inhalation Anesthesia (1937) and Fundamentals of Anesthesia (1942)

which was regarded as “Bible for Physician-Anesthetists” at that time [36]. In Great Britain as opposed to the U.S., anesthesia was developed as a physician specialty and was comparatively more developed. This pioneer group of wartime anesthesiologists gained valuable skills and knowledge from their service in European theater of operations. These physician anesthetists proved their competency in the wartime and this led to a greater respect for anesthesia as a profession and it became apparent that this is a field that is more suited for physicians [37]. These veteran anesthesiologists brought back sophisticated Intravenous and regional anesthetics skills. After the war many of these veterans developed an interest in anesthesia and sought more thorough instructions in anesthesia. Many of these “90 day graduates” subsequently joined ASA and/or ABA [38]. Among the trainees was Virgil K. Stoelting, who would go on to become the first chair of anesthesiology at Indiana University. Anesthesiologists nationwide called for a movement to establish independent anesthesiology departments at academic institutions.

This led to creation of Association of University Anesthesiologists (AUA) with aim of promoting free and informal interchange of ideas, development of anesthesia teaching and research. Emeul Papper served as the first president and AUA, whose first meeting took place in Philadelphia, attended by the founding group of eight [39].

Post-World War Years and the Structuring of Graduate Medical Education

In 1955, the ABA required all the applicants to dedicate five years exclusively to the practice of anesthesiology. Also, the applicants were required to submit “case history abstracts of personally conducted anesthesia procedures” to ABA, a predecessor to the online case log system existing today. In addition to the written and oral exam, the ABA also incorporated the “survey exam”, in which the applicants were observed in their own practice. The application fee for examination at that time was 125 US\$ [32].

The Residency Review Committee (RRC) in Anesthesiology was formed in 1957, with members from both the ABA and American Medical Association. Initially the anesthesiology residency was 2 years but beginning in 1962 the RRC allowed programs to offer a 4-year course, with the extra year spent doing sub-specialty training or doing research. In 1964 ACGME adopted a more standardized approach to the number of years and recommended three-year residency [40]. During the same year doctors of osteopathic medicine were also deemed eligible for ABA certification [40].

In 1966 Citizen's Commission appointed by AMA found serious inadequacies in the current system of graduate medical education (GME) [41]. The commission noted an ineffectiveness of existing institutions of GME and persistence of apprenticeship in training. Citizen's Commission report can be regarded as a significant step forward in development of graduate medical education in general which also naturally effected anesthesiology residency programs. This report led to the formation of the Liaison Committee on Graduate Medical Education (LCGME) in 1972 as a result of collaboration between five concerned authorities namely; AMA, the ABMS, the American Hospital Association, the Association of American Medical Colleges, and the Council on Medical Specialty Societies. The mission of LCGME (later renamed as ACGME in 1981) was to improve healthcare by assessing and advancing the quality of resident physicians' education through accreditation.

In the late 1970's and early 1980's LCGME extensively organized and laid out clear structural framework for anesthesiology residency programs. LCGME emphasized program structure, the amount and quality of formal teaching and promoted a balance between service and education. LCGME achieved this mandate by defining minimum requirements for anesthesiology programs, which became increasingly specific over the coming years. In 1980 the LCGME defined intern year for anesthesiology as the clinical base year which could be spent training in medicine, surgery, neurology, pediatrics or any combination of these with the approval of program director preferably at the same institution as the parent institution [42]. LCGME also recommended the curriculum for post graduate year 2 to 4 (termed as CA1- CA3), suggesting that at least one of the 24 months in CA1-CA2 be dedicated to “recovery room or specialized care unit”. Over the recent years ACGME has recommended increased rotation in ICU, as well as mandatory rotation in Pain service. In 1993 [43] ACGME set criteria for the appointment of program director to anesthesiology residency program. ACGME also made recommendations for the qualifications of the faculty, ratio of faculty to number of residents, scholarly activity and resident record maintenance.

1980's was a transformative period for anesthesiology education. In addition to the structural reorganization of anesthesiology by ACGME, ABA also refined its examination process in order to reduce the variability in examination process [33]. During the same time, the Society for Education in Anesthesia (SEA) was formed with an aim of promotion of education in anesthesiology. Over the years, eventually these guidelines and efforts from ACGME, ABA, and anesthesiology societies transformed anesthesiology residency from the rather unstructured model of the past to the well-controlled learning environment of today.

The 80 Hour Work Week Restrictions

Following the death of Libby Zion, purported to be secondary to medical error caused by resident fatigue; Bell Commission recommended an 80 h per week restriction on resident duty hour in 1987. Progress however was slow and the 80 h per week was not officially adopted by ACGME until 2003. As a result of the 80 h work week restriction residents now spend approximately 15,000 h in training compared to 30,000 h before. It is imperative that the sophisticated training techniques should be incorporated into residents training in order to produce well trained anesthesiologist [44]. Interestingly however, Stedman noticed that at Ochsner anesthesiology residency program the work hour restriction caused no loss in total caseload (number of anesthetics administered per resident per year in 2006 was 411 vs. 304 in 1990). He attributed this to the increased OR efficiency and the increased number of cases residents performs in the newly formed regional anesthesia rotation [22].

The ACGME 80 h anesthesia resident work week did cause significant financial implication for Institutions which were used to having inexpensive labor in the form of anesthesia residents. Backeris et al. calculated the cost to replace residents with CRNA was between \$236,000 to \$581,876, assuming a 50 h resident work week, and \$373,400 to \$931,001, assuming an 80 h resident work week [45].

The Inoculation of Research in Anesthesia Education

One of the distinctions of an anesthesiologist from their nursing counterparts is the contribution they make to the development of the specialty by continuously trying to improve practice based on

evidence. ACGME requires the faculty to create an environment of inquiry and for the programs to provide mechanisms and resources for the residents to conduct research and scholarly activity. There is constant emphasis on participation of the residents in scholarly activity. Residents are expected to learn skills to critically appraise the literature for its validity for future practice. There is however, a concern that there is not enough contribution to research in anesthesiology as compared to some of the peer specialties. Schwinn et al. [46] reported that while anesthesiologist make up 6% of the work force but they only received about 1% of NIH funding. There is a need to train more physician scientists. Incorporating research curriculum into resident education can help them be more academically productive [47-49]. A survey by Ahmad et al. showed that thirty-two percent of programs had a structured resident research education program. While the ACGME places a great deal of emphasis on the importance of research training in a residents' education, it seems that progress is slow in this aspect as well. It would probably require a change in the culture of academic anesthesiology to ensure the mandatory enhancement of resident research education [50]. Sakai et al. [51] observed how the implementation of research didactics including research lectures, research problem based learning discussions, and an elective research rotation translated into greater resident research involvement and publications. Similarly, Freundlich et al. [52] described how a month long research month proved to be a successful educational intervention at University of Michigan anesthesiology residency program. Recently as many as 35/131 (23%) of the approved ACGME residency programs have started offering a dedicated research track [53]. It seems likely that in coming years, anesthesiology departments will continue to devote more time and resources to ensure that anesthesiology residents are well trained in the research methodology; so they can continue to contribute to development of anesthesiology as a profession.

ACGME Core Competencies and Outcome Project

The traditional model of assessment in anesthesiology has been global clinical evaluation and standardized testing. There is a general notion that performance on standardized examinations can be used to predict clinical performance however this claim was not substantiated in any study and there was no direct correlation with actual clinical performance and standardized clinical measures for the same resident [54]. There has been a gradual evolution in anesthesiology education to nontraditional assessment methods that stimulate learning including self-assessment, peer review and simulation based learning.

Over the years the training model transformed from the traditional model to an outcome based model with focuses on learning and teaching of six core competencies [55,56]. These competencies as defined by ACGME are [57]:

1. **Patient Care:** that is compassionate, appropriate, and effective for treating health problems and promoting health;
2. **Medical Knowledge:** about established and evolving biomedical, clinical, and cognate (e.g., epidemiological and social-behavioral) sciences and the application of this knowledge to patient care;
3. **Practice-Based Learning and Improvement:** that involves investigation and evaluation of their own patient care, appraisal, and assimilation of scientific evidence, and improvements in patient care;
4. **Interpersonal and Communication Skills:** that result in effective information exchange and teaming with patients, their families, and other health professionals;

5. **Professionalism:** as manifested through a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population;

6. **Systems-Based Practice:** as manifested by actions that demonstrate an awareness of and responsiveness to the larger context and system of health care and the ability to effectively call on system resources to provide care that is of optimal value.

These six core competencies were introduced by ACGME in 1999 and gradually integrated into the residency curriculum in the 2000's. Schwengel et al. [58] described how they introduced Systems-Based Practice (SBP) and Practice-Based Learning and Improvement (PBLI) at John Hopkins Anesthesiology Residency Program. The CA-1 residents participate in a curriculum composed of lectures, interactive sessions and exercises designed to develop conceptual understanding of a wide range of topics, including fundamentals of safety and safe design, how to critically evaluate the literature and how to investigate defects. In the CA 2 and CA 3 years, residents work on an SBP improvement project.

The results of ACGME restructuring gradually became apparent. Variability in the quality of anesthesiology resident education decreased around the country. However, these ACGME minimum program requirements for anesthesiology curtailed the programs from innovation and added administrative burden to the program [59]. The National Interest in patient safety and outcomes measure lead ACGME to come up with The Outcome Project which mandated that residency programs teach six core competencies, create reliable tools to assess learning of the competencies, and use the data for program improvement. In 2014, ACGME implemented Next Accreditation System (NAS) for anesthesiology a program in which accreditation was to be based on educational outcomes in these competencies. It has been suggested that the New Accreditation System will allow better programs to innovate while allowing struggling programs to improve; all while decreasing the amount of administrative work done by the program director [60].

A key element of the NAS is the measurement and reporting of outcomes through the educational milestones. As the ACGME is moving toward continuous accreditation outcomes-based milestones which are specific for anesthesiology, are used for determining resident and fellow performance within the six ACGME Core Competencies [61]. These milestones result from a close collaboration among the ABA, the review committees, medical- specialty organizations, program-director associations, and residents.

The Development of Subspecialty Anesthesia

During 1960's interest increased in research and in sub-specialty anesthesiology training. A small number of anesthesiologists mostly at the larger academic centers would spend time focusing on, and doing research on particular cohort of patients. All these factors lead to advancements in knowledge of physiology and pharmacology with introduction of drugs such as fentanyl and ketamine. Similarly considerable scientific progress was made in critical care and the pediatric anesthesia. In 1959 Peter Safar established first multidisciplinary adult and pediatric ICU in the US at Baltimore City Hospital. In 1967 John Downes and Leonard Bachman established the first pediatric Intensive Care Unit (PICU) in US at Children's Hospital of Philadelphia [62].

Keeping up the development in subspecialty Anesthesiology, ABA mandated subspecialty rotations starting in 1980. In 1985 ABA began to issue certificate in Critical Care. In 1991 Pain Management (renamed Pain Medicine in 2002) was recognized as a subspecialty by ABA. And most recently in 2012 ABA approved an additional time-limited pediatric anesthesiology certificate. Currently the ACGME requires all residents to have a specified minimum recommended amount of subspecialty anesthesia rotations.

Combined Anesthesia Residencies

In 2009 American Board of Pediatrics and ABA announced combined training in pediatrics and anesthesiology. This program requires five, rather than six, years of training and allows physicians to be fully qualified and certified in both specialties [63]. As of 2014, there are 7 combined Anesthesiology/Pediatrics program training about 22 residents (FREIDA Online specialty training [<https://freida.ama-assn.org/>]). Interest in combined pediatrics-anesthesia training is growing among applicants [64].

The American Board of Internal Medicine (ABIM) and the ABA began a combined training program in Internal medicine and Anesthesiology in January 2012. As of 2016, there are 5 approved programs for combined residency training in Internal medicine and Anesthesiology [65].

Future of Anesthesiology Education-A Blended Educational Model

The advents in information technology in the past decades have also impacted anesthesiology education. Simulation has become an integral part of residency training. Simulation allows residents to experience clinical scenarios that are infrequent in daily practice, but critical to anesthesia practice such as anaphylaxis, airway fire or the use of bronchial blockers and double-lumen endotracheal tubes (ETT) for single lung isolation [66]. As of 2014 ACGME requires at least one simulation training session for residents every year.

With the 80 h work limit, educators are hard pressed to make anesthesiology training as enriching as possible. Educators are trying to find new and innovative ways to introduce technology in anesthesia education. Tanaka et al. [67] showed how the use of an iPad® in a two week anesthesiology rotation at Stanford University objectively increased residents' perception of overall teaching quality of the rotation. Educators are trying to shift to a blended educational model with podcasts, videos, online quizzes and other online educational modalities [68]. This has been somewhat difficult to achieve owing to the intrinsic nature of anesthesiology which requires face to face and hands-on training. There have been varying results on usefulness of different modalities and the effectiveness of these tools depends more on the learning style of the resident. However, it seems likely that with coming time anesthesiology training will evolve to utilize and incorporate more technological advances such as simulation training and e-learning. In conclusion, it is remarkable to see how a specialty that had its humble origins in a self-taught and practiced unstructured training has evolved into this well-planned and regulated educational system producing highly competent physicians that have been trained in all the domains that will help them succeed in providing high quality patient care as well as advance this discipline in the future.

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