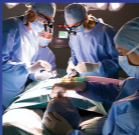


Anesthesiology

THIRD EDITION



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Anesthesiology

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"Life is no brief candle to me; it is a sort of splendid torch which I've got a hold of for the moment and I want to make it burn as brightly as possible before handing it on to future generations."

George Bernard Shaw
Irish playwright (1856–1950)

The editors were fortunate indeed to have outstanding mentors who dedicated their professional lives to the development of our generation in the specialty. Through their guidance, wisdom, and actions, they truly handed the torch to us. As their progeny, we are ever grateful for both their professional guidance and their personal friendship. In recognition of their influence on us individually, and the specialty overall, we dedicate this book to:

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Preface

Anesthesiology, and indeed all of US health care, is influenced currently by four dominant trends. First, the passage of the Patient Protection and Affordable Care Act (PPACA) of 2010 demonstrated an enhanced national commitment to access to health care. Second, it underscored that such care must be affordable, that is, more efficient and cost effective. These two principles are now well established and will likely persist, although structural details may vary depending on national policy and political preference. Third, the emphasis on quality and safety in health care has gained even greater momentum. Fourth, the national burden of illness is magnified by a US population that is aging rapidly, resulting in over 10,000 new Medicare enrollees daily. Collectively, these trends have led to the development of alternative payment models that reward value, not volume of services, and that further emphasize the role of patient choice in the care process. We believe these trends will be dominant themes for many years to come, and they are guiding principles in the current edition of this text.

Fortunately, the specialty of anesthesiology is well positioned to lead these initiatives. Anesthesiology is already recognized as the pioneering leader in patient safety, and we see no reason why anesthesiologists and anesthesia teams should not be leaders in efficiency, value, and patient choice in health care as well. Indeed, we believe that continuing to position our specialty at the forefront of these initiatives is a key strategy for both the current and future success of anesthesiology and its practitioners.

In 2000, the Institute of Medicine (IOM; renamed the National Academy of Medicine in 2015) published its landmark analysis of American health care, "To Err Is Human," a treatise that emphasized the fallibility of even highly motivated humans and that systems of safe care must be constructed to protect patients from potential harm. That report specifically cited anesthesiology as a leader in the patient safety movement and urged other disciplines to follow, which many have done subsequently. Another IOM publication, "Crossing the Quality Chasm: A New Health System for the 21st Century" (2001), described the attributes of a model health care system that is safe, timely, efficient, effective, patient centered, and equitable to all.

The PPACA legislation underscored these principles, and subsequent regulations translated them into operational policies and practices. We agree with these principles and have worked diligently to adopt them in our own practices and departments, for they are guideposts to the professional and ethical practice of health care and anesthesiology. Further, we have designed this text around the concepts of safe, effective, efficient, and patient-centered care, and we urge all clinicians to approach their practice with a similar commitment to these principles.

Our goal is to provide the practitioner with a single resource that captures the essence of the full spectrum of anesthesia practice. There are multiple sources of information about anesthesiology, but many ignore the full breadth of the practice. Further, there are numerous focused

texts that delve into specific subdisciplines in great detail, often more detail than the trainee or practitioner desires or needs.

In this text, we focus on what is truly important for the clinical practice of anesthesiology in all its dimensions, while being efficient in the presentation of this essential material. Throughout, we have asked: What is important? Why is it important? When should it be applied? and How should it be applied? In brief, we have written for practitioners, not physician scientists. That said, this is not a user's manual of anesthesia care, but rather a text that constantly builds on the concepts of safe, effective (i.e., evidence-based), efficient, and patient-centered care, distilled in a manner that facilitates easy access to the key scientific concepts that underpin high-quality practice. Thus, one finds Key Points and Key References in each chapter, while an extensive reference list is provided online for those who seek in-depth research-based documentation.

Throughout, we embrace an encompassing view of modern anesthesiology practice, underscoring the role of the anesthesiologist as perioperative physician. We emphasize important trends, both in the specialty and in health care in general, to ensure that the reader is not required to go elsewhere for additional information to support the mainstream of their practice. These trends include team-based anesthesia care, the remarkable explosion in pain medicine practice, and the expanded need for practitioners who are skilled in the practice of critical care medicine. No careful observer of the specialty could miss these trends, and no text could be considered "comprehensive" if it did not embrace them as full components of the modern practice of anesthesiology.

Further, we have woven the concepts of quality, safety, cost-effectiveness, and value into the text by emphasizing that perioperative anesthesia care is one system of care within a larger system of care that focuses on overall patient outcomes, not independent events by individual practitioners working in isolated clinical disciplines.

We have approached these and other key "drivers" of contemporary and future anesthesia practice with care, commitment, and enthusiasm for the future of the specialty. We trust that you share this enthusiasm and hope our efforts will serve you well as you continue to translate your knowledge and skills into safe, effective, efficient, and patient-centered care; our patients want nothing less, and our surgical and medical colleagues are looking to anesthesiology to continue to set the example for implementation of these principles. We are honored to serve you through our efforts here.

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Introduction to Anesthesiology

CHAPTER

1

Evolution of Anesthesiology as a Clinical Discipline: A Lesson in Developing Professionalism

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KEY POINTS

1. The history of anesthesiology is an interesting and complicated story of professionals seeking to understand the anesthetic state and to safely anesthetize patients.
2. Shortly after the first public demonstration of ether anesthesia on October 16, 1846, by William Thomas Green Morton, the news spread across the world. Initially, anesthetics were administered based on written descriptions in the lay press.
3. London physician John Snow worked out the physics of vaporization of volatile agents by observation of ether and chloroform and used this information to design vaporizers and anesthetic techniques that were safer for the patient.
4. The first professional organization devoted to anesthesia was the London Society of Anaesthetists, founded on May 30, 1893. The first similar group in the United States was the Long Island Society organized by Adolph Frederick Erdmann on October 6, 1905. This eventually became the American Society of Anesthesiologists.
5. Francis Hoffer McMechan organized professional anesthesia in 1912 by helping to create the first national organization, the Associated Anesthetists of America, and went on to found several national and international organizations, of which the International Anesthesia Research Society (IARS) remains active. He was the founding editor of the first journal in the world devoted to the specialty, *Current Researches in Anesthesia and Analgesia*, which is currently published as *Anesthesia and Analgesia*.
6. Ralph Waters is credited with founding the first academic department of anesthesia at the University of Wisconsin in 1927. Much of the current residency structure comes from this seminal department. This helped establish the specialty on an equal footing with other medical specialties.
7. John Lundy at the Mayo Clinic organized the Anaesthetists Travel Club, whose members were the leading young anesthetists of the United States and Canada. These individuals helped create the American Board of Anesthesiology (ABA), which defined what it meant to be an anesthesiologist in the United States.
8. The need for specialists in World War II exposed a large number of young physicians and nurses to anesthetic practice. After the war, physicians returned and helped create the tremendous growth of anesthesiology in the 1950s-1960s, while the nurses greatly expanded nurse anesthesia.
9. In the mid-1950s, the World Federation of Societies of Anesthesiologists (WFSA) was formed, which culminated from a dream that began in the late 1930s. The WFSA made it possible for nations with a long tradition of physician specialization in anesthesia to help train practitioners and introduce the specialty to new countries.
10. In the 1980s, the Anesthesia Patient Safety Foundation (APSF) and the Foundation for Anesthesia Education and Research (FAER) were created. They are additional examples of the professionalism demonstrated by physician leaders throughout anesthesiology's history. These organizations work to create a safe anesthetic environment and to support educational and research efforts in the specialty.

INTRODUCTION

The quest for insensibility to the surgeon's knife is a primordial one. Stretching back to antiquity, physicians have sought ways to render a pain-free surgery. Many different regimens were tried with varying success until October 16, 1846, when surgical anesthesia was publicly demonstrated by William Morton at Massachusetts General Hospital. Yet, there remained a long road to the current operating room full of electronic machines whose sole purpose is to measure the physiologic parameters of the anesthetized patient. How did anesthesiology evolve from a simple glass globe inhaler to the vast array of machines that makes the modern operating room?

The history of anesthesiology is the history of those who have devoted their career to the administration of anesthetics. Without physicians interested in the anesthetic state and the ability to adapt to new conditions demanded of anesthesiologists by surgeons, there would be neither modern surgery nor the specialty of anesthesiology. Many individuals displayed professionalism beyond what was required or expected; others seem reprehensible by "modern" standards. Although many would not consider themselves specialists in anesthesia, their contributions were critical in advancing the specialty. The development of anesthesiology can be told as the history of involved physicians who dedicated themselves to providing safer, more focused care of the patient, first in the operating room and later in the critical care unit and pain clinic. The story begins in ancient Egypt and continues to evolve in untold ways.

PREHISTORY: THE QUEST FOR SURGICAL ANESTHESIA

Imagine for a moment that there is no surgical anesthesia. The Edwin Smith Papyrus describes 48 surgical cases done from 3000 to 2500 BC. Although no specific anesthetic agent is mentioned, within the papyrus there is evidence of compression anesthesia. In one instance, a surgeon compresses the antecubital fossa while operating on the hand; in another instance, the patient compresses his brachial plexus while the surgeon operates on his palm.¹ The ancient Chinese reported the use of an anesthetic for surgery in the 2nd century BC.² The use of hemp smoke as an anesthetic was noted in India³ long before Western medicine developed crude forms of anesthesia.

During the Middle Ages and early Renaissance, a mixture of herbs boiled into a sponge was created to induce anesthesia. At the time of surgery, the sponge was placed in water and the vapors inhaled. Although the vinca alkaloids were a major component of the drugs used in the *spongia somnifera*, the resultant anesthetic was less than satisfactory. Another Renaissance solution was the use of parallel lines of ice placed around the incision. This was effective for simple operations and found use in the Russo-Finnish War of 1939-1940.⁴ Alcohol consumed in sufficient quantities was noted to render individuals insensible and was thus used as a standard against which all anesthetics could be measured.³

By the 1840s, the effects of nitrous oxide and diethyl ether were already well known. Medical students knew them as intoxicants. In 1800, Humphry Davy described the intoxicating effects in his book, *Researches Chemical and Philosophical: Chiefly Concerning Nitrous Oxide*. Ether, first synthesized in the 1500s, had been observed to lessen the “air hunger” of asthmatics.⁵ In January 1842, in Rochester, New York, medical student William E. Clark anesthetized a classmate’s sister using ether for a molar extraction. Instructed not to pursue this observation as it most likely was a “hysterical reaction of women,” Clarke continued his training and became a respected Chicago area physician.⁶

Two months later in rural Georgia, Dr. Crawford Long, who had hosted parties where ether was used as an intoxicant, used the drug to render James Venable insensitive to the removal of tumors from his neck. Long charged Venable \$2 for the anesthetic, thus delineating anesthesia as part of a physician’s professional service. In 1844, Hartford, Connecticut, dentist Horace Wells discovered during a show that when an individual was intoxicated by nitrous oxide, pain was abolished. Wells himself underwent a painless tooth removal performed by his partner using nitrous oxide. Soon, he was using “painless dentistry” as part of his professional advertisement. He even attempted to demonstrate a painless tooth extraction at Massachusetts General Hospital in 1844, but although the patient had no memory of the event, it was considered a failure because he groaned during the demonstration.⁷

By the mid-1800s, there were sufficient observations about specific agents that could potentially abolish surgical pain. In rural Jefferson, Georgia, surgery with ether anesthesia was occurring on a limited scale. Yet, Long felt he lacked sufficient cases to study the effects of this new agent.⁸ Wells’s use of nitrous oxide was groundbreaking, but he lacked the emotional stability to overcome his failed demonstration.⁹ Thus, the stage was set for another dentist to demonstrate reproducible surgical anesthesia, giving birth to what would become the specialty of anesthesiology.

DISCOVERY

On October 16, 1846, Morton provided surgical anesthesia for Gilbert Abbott for the removal of a jaw tumor at Massachusetts General Hospital.¹⁰ On completing the operation, surgeon John Collins Warren remarked, “Gentlemen, this is no humbug.” The miracle of pain-free surgery so impressed the Boston medical establishment that letters were sent to colleagues across the world. Considerable scholarship has been spent discerning when and where these letters arrived and who first provided anesthesia in each new location. The generally accepted view of the spread of anesthesia to the United Kingdom is a letter from Jacob Bigelow to Francis Boot. However, by careful study of the ships sailing between Boston and Liverpool, another letter, written almost 2 weeks before Bigelow’s and only 12 days after the public demonstration of ether, arrived in England on November 1, 1846. Interestingly, this letter was to a patent attorney.¹¹

Morton wanted to patent the process of administering ether and wrote to the foremost patent attorney in England to secure rights in the United States and United Kingdom⁹ and perhaps the world. He even tried to patent ether itself, calling his anesthetizing mixture “Letheon.” However, ether’s distinctive odor gave away the true nature of the concoction. The Boston medical establishment had convinced Morton to allow Massachusetts General Hospital to use Letheon free of charge. Unfortunately for Morton, because ether was well known and easy to synthesize and its effects reproducible without “Morton’s Inhaler,” the patent was unenforceable. He would spend the rest of his life seeking compensation for patent infringement, fighting with the medical establishment into the halls of Congress.⁸ Morton clearly was not the embodiment of medical professionalism as we understand it today.

Given the nature of communication in the 1840s, news of Morton’s achievement traveled quickly. On December 16, 1846, ether anesthesia arrived in London in the form of a letter. On December 19, the first ether anesthetic was given in the United Kingdom for a tooth extraction. On December 21, the famous surgeon Robert Liston amputated a butler’s leg and uttered the words, “This Yankee dodge beats mesmerism hollow.” By early 1847, anesthetics were being given across Europe. By June 1847, news had spread to Australia.¹² Peter Parker, minister and physician missionary, on October 4, 1847, gave the first anesthetics in China.¹³

For the history of the specialty of anesthesiology, what is interesting is how willing physicians and dentists were to use ether to induce insensibility. Consider for a moment that outside Boston, no one had actually witnessed surgical anesthesia. Many accounts, especially those reaching South Africa and Australia, were newspaper articles or letters to the editor, often signed by a pseudonym. The hope that these medical professionals had, their desperation to adequately alleviate pain, and their desire to help patients may have been the motivation to try this new technique. Yet, when viewed from the perspective of current early 21st century medicine, this willingness to go on purely written accounts, often in the lay press, without the collaborating voices of the medical profession, seems dangerous and without regard for the basic principle of medicine: first do no harm.

And, what of the surgeons? Surgical pain limited operations to those that could be performed quickly. Anesthesia obviated the need for speed, presenting the possibility of operating within the visceral cavities for hours rather than seconds. But, as the physicians responsible for the patient, long before the specialty of anesthesiology would be defined, we wonder why these professionals were willing to risk lives to find an anesthetic. What does this say to the modern student of medical professionalism?

JOHN SNOW, SPECIALIZATION, AND EARLY PROFESSIONALISM

As reprehensible as Morton’s actions appear in patenting his “discovery,” Morton was acting within the ethics of his time. The American Medical Association (AMA) was only just beginning. Five months before the public demonstration of ether, the National Medical Convention met for the first time in May 1846 and began to write a code of medical ethics; 1 year later, the code was adopted. Morton’s actions were covered under section 4:

Equally derogatory to professional character is it, for a physician to hold a patent for any surgical instrument, or medicine, or to dispense a secret nostrum, whether it be the composition or exclusive property of himself or others. For, if such nostrum be of real efficacy, any concealment regarding it is inconsistent with beneficence and professional liberality.¹⁴

Thus, at the time Morton was trying to patent ether and its vaporization apparatus, the medical field was issuing statements against such behavior.

In contrast, London physician John Snow (**Figure 1-1**) began to study the chemical and physical properties of ether and by 1847 had developed a vaporizer. However, unlike Morton, “Snow never patented any



FIGURE 1-1. John Snow. [Used with permission from Wood Library-Museum of Anesthesiology.]

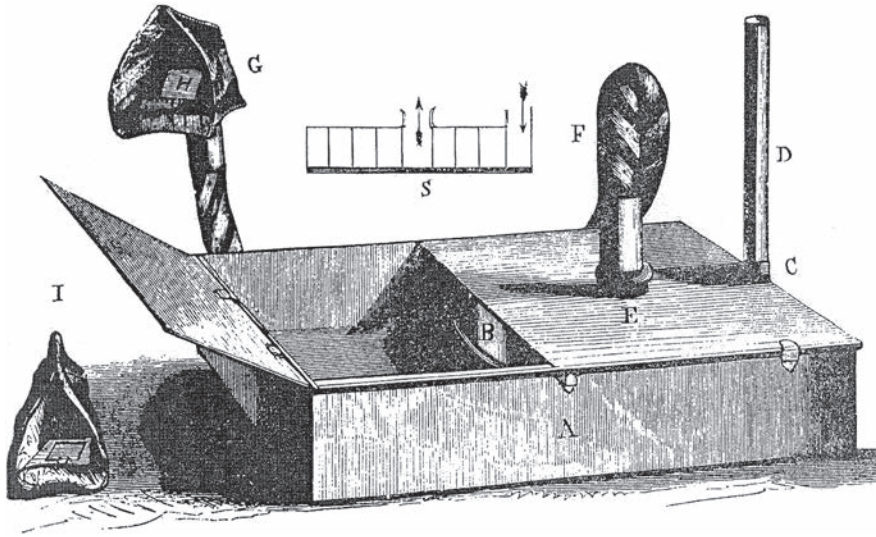


FIGURE 1-2. Snow's vaporizer. [Used with permission from Wood Library-Museum of Anesthesiology.]

apparatus he designed. On the contrary, he published clear descriptions, including engraved figures, so that others could copy them if they chose.¹⁵ By careful observation, he discerned ether's vaporization characteristics. His vaporizer (Figure 1-2) was made of coiled copper (Figure 1-3), an excellent heat-conducting metal, housed in a water bath to ensure constant temperature of the ether. Thus, Snow was able to calculate the amount of ether a patient would require within a few years of the discovery of anesthesia.¹³

Following the introduction of chloroform as an anesthetic in 1847 by Edinburgh obstetrician James Young Simpson, Snow also began to investigate it. He used his experience with ether as a guide for investigating chloroform's properties. He concluded that it was far safer to give this new anesthetic in measured quantities through an inhaler as opposed to the handkerchief method, whereby chloroform was applied to a cloth and held close to the nose and mouth because the anesthetic depth of the patient could not be adequately controlled. Snow's deliberate nature and strong powers of observation allowed him to create a calibrated, temperature-compensated chloroform vaporizer.¹³

Snow is unique among his London colleagues. In a day when operations were still rarely performed, Snow specialized in anesthetics. In some ways, his expert knowledge allowed him entrée into the upper echelons of both social and physician circles. Perhaps this is best illustrated by his care of Queen Victoria for the birth of her last two children. While Snow did not use his inhaler for the Queen, he also did not induce a full anesthetic state. Rather, he strove for analgesia with chloroform, thus creating a form of obstetrical analgesia, *chloroform a la reine*, which would persist in various forms over the next century.¹³

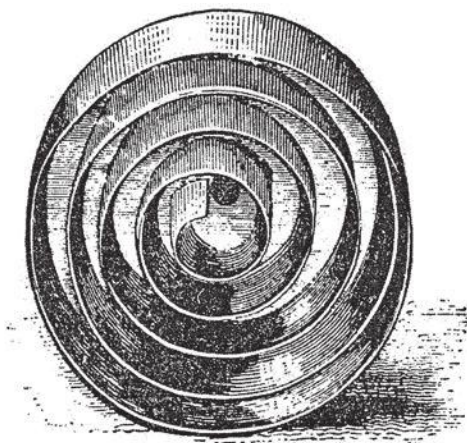


FIGURE 1-3. Coil from Snow's vaporizer. [Used with permission from Wood Library-Museum of Anesthesiology.]

Aside from discerning the physics of vaporization, Snow was intensely interested in outcome data. He studied every report concerning a death under anesthesia and often had data in advance of the published death reports. He commented extensively on Hannah Greener's death, thought to be the first death under anesthesia in the world.¹⁶ In his posthumous book, *On Chloroform and Other Anesthetics*,¹⁷ published in 1858, Snow compiled the first 50 deaths under chloroform with comments about the pathophysiology present. His spirit of inquiry, which extended from benchtop to autopsy, helped him to understand the nature of the anesthetic process and the agents that produced insensibility, thus the scientific underpinnings of a specialty.¹⁸

A PROFESSION EMERGES

After Snow's untimely death in 1858, anesthesia faded into the medical background. In larger cities, there were those who made a majority of their clinical income from providing anesthesia, yet it would not be until the advent of Listerism and the "taming" of infection that operations would become more frequent. As the number of operations increased, so did the need for anesthesia, and unfortunately, mortality became an issue. Chloroform was responsible for seemingly inexplicable deaths. Ether appeared to be safer, yet its side effects of nausea and vomiting and its prolonged induction compared to chloroform's made it less than ideal. Surgeons began to search for alternative methods for the administration of anesthetics.

In 1884, Carl Koller, an ophthalmology resident in Vienna, was introduced by Sigmund Freud to a new crystalline substance called cocaine. Koller sought a local anesthetic to replace ether anesthesia for eye operations. Because fine suture material to close the eye wound did not yet exist, any postoperative retching could potentially cause vision loss. Therefore, when Koller's tongue became numb from droplets of a solution containing cocaine, he made the conceptual leap that this same solution could be applied to the cornea with similar anesthetic effects. Before long, he had numbed the eyes of several animals, a fellow investigator, and himself. He took this new topical anesthetic to the clinic and used it with great success. On September 15, 1884, Koller's paper on the subject was accepted at the German Ophthalmological Society meeting in Heidelberg. But, because Koller was unable to afford travel expenses, his colleague, Dr. Josef Brettauert, presented the paper for him.¹⁹

While Koller continued his career in ophthalmology, eventually immigrating to the United States, other physicians modified this new form of anesthesia into an alternative to general narcosis. One of the early practitioners was William Halstead, future chair of surgery at Johns Hopkins University, who was in Vienna at the time of Koller's discovery. Using cocaine topically, Halstead dissected down to a nerve and directly anesthetized it. Much of his work he did on himself, regrettably leading to a cocaine addiction.²⁰ Another of the pioneers of regional anesthesia was German surgeon Carl Ludwig Schleich, who developed the

technique of infiltration anesthesia.²¹ Combining infiltration techniques with the newly discovered lumbar puncture, another academic German surgeon, August Bier, initiated spinal anesthesia in the late 1890s. Working with his fellow, August Hildebrandt, Bier successfully cannulated the subarachnoid space of Hildebrandt and produced a satisfactory anesthetic state. Hildebrandt was unsuccessful in cannulating Bier's subarachnoid space; however, both men suffered postdural-puncture headaches.²² Ten years later, Bier described an intravenous regional anesthetic technique, which is still known as the Bier block.²³

At the same time that regional anesthesia was being developed in Germany, concern over the safety of chloroform, especially when compared to ether, was developing. In India, then a colony of England, a Chloroform Commission was seated in Hyderabad in an attempt to determine which anesthetic agent was safest. Funded by the Nizam of Hyderabad, the 1888 study of anesthetic agents was an effort to discover whether there was an intrinsic mortality associated with chloroform. Sadly, the findings were tainted by the British medical officer in charge, Dr. Edward Lawrie, a strong chloroform proponent who trained in chloroform's birthplace of Edinburgh. The findings of the Hyderabad Chloroform Commission were tainted, and a second commission was ordered, which also was inconclusive. Yet, what was important in these commissions is that physicians were studying anesthesia and trying to increase patient safety. For many physicians, it was slowly becoming apparent that there was a need for a specialty practice of anesthesia.²⁴

In the early 20th century, the AMA set up a commission to study anesthetics and in 1908 issued a preliminary report.²⁵ All forms of anesthesia were accounted for, including spinal anesthesia and various combinations of inhalational agents. The conclusions of the report are interesting and foreshadowed the development of a separate specialty:

All the newer methods demand expertness, experience, and special apparatus. They appeal especially to the surgeons who are equipped with the paraphernalia of expensive and highly specialized clinics. They are little suited to physicians in general practice. For the latter great class of practitioners, the old general anesthetics, chloroform and ether, will probably hold their own until increasing experience has enabled us to simplify and to make safe the newer and more novel methods.²⁵

The commission had three interesting recommendations:

1. For the general practitioner and all anesthetists not specially skilled, ether administered by the open-drop method must be the anesthetic of choice.
2. The use of chloroform, particularly for minor operations, is discouraged unless given by an expert.
3. The training of skilled anesthetists is encouraged, and undergraduate students should be more generally instructed in the use of anesthetics.²⁵

The last suggestion of the commission took two interesting paths. In many of the operating rooms across the United States, nurses began to administer anesthetics. More reliable than the casual anesthetist, these individuals developed great skill, especially in the administration of open-drop ether. At the Mayo Clinic in Rochester, Minnesota, the nurses were renowned for their skill; physicians and other nurses traveled across the country and the world to observe and learn this skill. Alice Magaw, perhaps the most famous of the early Mayo Clinic nurse anesthetists, published a series of articles at the turn of the century outlining her techniques.²⁶

THE RISE OF THE SPECIALIST

The second path, that for the physician specialist, would take the better part of the 20th century. On October 6, 1905, a group of eight physicians and a medical student in Brooklyn, New York, led by Adolph Frederick Erdmann (Figure 1-4), gathered to discuss the problem of anesthetics. Like the AMA commission, these young physicians believed that there was more to giving an anesthetic than simply dropping ether on a cloth held near a patient's face and that there needed to be discussions and a free exchange of scientific and practical information.²⁷ This was the second specialty group in the world that was created, the first being the London Society of Anesthetists in 1893, and it would become the catalyst for the development and recognition of physician specialists in anesthesia.²⁸ Thus, the Long Island Society of Anesthetists (LISA) was

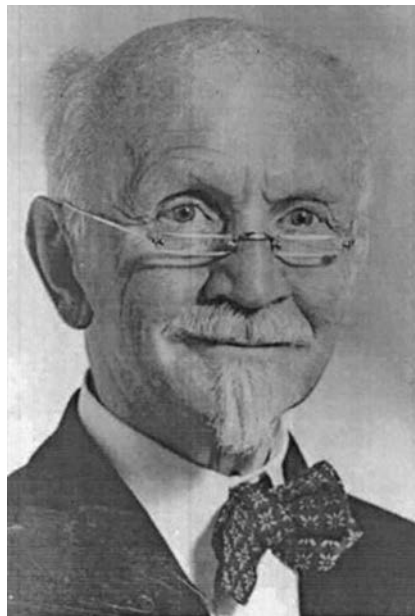


FIGURE 1-4. Adolph Frederick Erdmann. [Used with permission from Wood Library-Museum of Anesthesiology.]

born. The society met quarterly with a short business meeting followed by the presentation of two or three papers and perhaps the demonstration of a new anesthetic technique or apparatus. Science aside, the society provided a "support" group for those seeking to improve their anesthetic skills and a forum to exchange ideas and to deal with problems beyond the science of anesthesia.²⁷

The group flourished, and in 1912, it moved to New York City and was renamed the New York Society of Anesthetists (NYSA). By the mid-1920s, the group encompassed the entire state of New York, and by 1936, it had become a national organization.²⁹ Its transformation focused on the recognition of physicians who primarily anesthetized patients as specialists.

The first significant political move of the NYSA was a motion put before the AMA House of Delegates, asking for a section on anesthetics in 1912. The NYSA was concerned about nonphysicians giving anesthetics and echoed some of the findings of the AMA's Commission on Anesthetics 6 years earlier.²⁹ James Gwathmey (Figure 1-5),



FIGURE 1-5. James Tayloe Gwathmey. [Used with permission from Wood Library-Museum of Anesthesiology.]



FIGURE 1-6. Francis Hoeffler McMechan. [Used with permission from Wood Library-Museum of Anesthesiology.]

the society's president, was developing a new method of anesthesia—rectal ether. Like chloroform, rectal ether could be unpredictable and needed to be administered by someone familiar with its use and with the effects of anesthesia in general.³⁰ The quest for a section within the AMA was, in some ways, the beginning of a quest for patient safety in anesthesia, a movement that would take the specialty by storm in the late 20th century.

The motion was denied by the AMA House of Delegates, but Gwathmey and Francis Hoeffler McMechan (**Figure 1-6**) gathered the defeated physician anesthetists and created the American Association of Anesthetists (AAA). This was the first national group of physician anesthetists in the United States. They met the following year (1913) for a day of papers, mostly clinical in origin, followed by a dinner with spouses (**Figure 1-7**). A day devoted to the science of anesthesia is memorable;

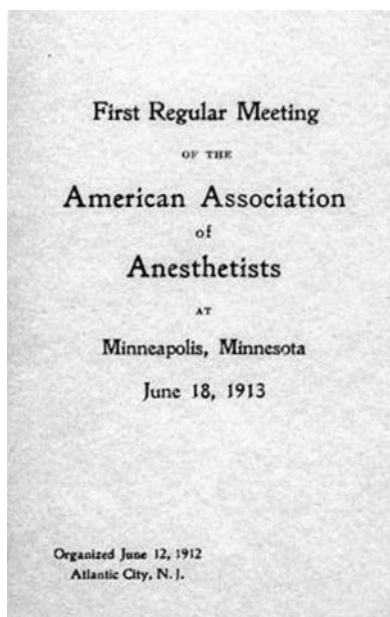


FIGURE 1-7. Program of the first meeting of the American Association of Anesthetists, June 18, 1913, Minneapolis, Minnesota. [Used with permission from Wood Library-Museum of Anesthesiology.]

it signified a group, however small, that was willing to be recognized as specialists in anesthetics, uniting to move the field forward.²⁹

The AAA, and its successor, the Associated Anesthetists of the United States and Canada, were run by McMechan. A third-generation physician who entered anesthesia against the advice of his physician father, McMechan developed crippling rheumatoid arthritis and was out of clinical practice by 1911. He was a visionary who desired to see anesthesia “stand shoulder to shoulder” with surgery and internal medicine on a worldwide scale. He realized that without a place to publish papers on the specialty and without a place to gather the news of the various societies and names of physicians practicing anesthesia, the specialty would be doomed. McMechan convinced his friend Joseph McDonald, the editor of the *American Journal of Surgery*, to publish a supplement on anesthesia, giving the physician specialty its first US quarterly. McMechan also edited the *Yearbook of Anesthesia* from 1914 to 1919, compiling all of the papers published in the specialty in the preceding year into a single volume.³¹

McMechan understood that the specialty would never develop as a discipline within medicine without a strong scientific underpinning, so he organized a society devoted to research in anesthesia, first nationally, then internationally in the mid-1920s. The International Anesthesia Research Society (IARS) brought together basic science researchers and the physicians most in need of their talents. Most important, the IARS sponsored the first journal in the world devoted to anesthesiology, *Current Researches in Anesthesia and Analgesia*.³²

The education of physician specialists, especially in the postgraduate period, was another of McMechan's concerns. Partnering with Ralph Waters, an opportunity emerged at the University of Wisconsin in 1926 as its medical school transformed itself from a 2-year institution offering only basic science education into a 4-year curriculum with all clinical sciences. One addition was a section on anesthesia, headed by Waters, in the department of surgery. Waters immediately began to teach anesthesia to medical students and interns. He collaborated with basic science researchers, first on problems of carbon dioxide absorbance and later on all aspects of anesthesiology through various members of his department. Perhaps most important, Waters established the first residency training program in an academic center, which was 3 years beyond the intern experience. Years 1 and 3 were clinical, while year 2 was devoted to laboratory research. Two weekly conferences were established, one discussing the week's cases in a format similar to current morbidity and mortality conferences and another devoted to current anesthesia literature. By 1933, the teaching program was the envy of the world, and Waters understood that one final step had to be taken. He sent one of his faculty members and an early graduate of the program, Emery Rovenstine, to Bellevue Hospital and New York University to try to replicate the University of Wisconsin department. Rovenstine was successful beyond any expectation, and in some ways, his graduates would eclipse the contributions of Waters's graduates in the development of academic anesthesiology.³³

In 1929, the Anaesthetists Travel Club was organized by John Lundy at Mayo Clinic. The group was created along the lines of the Society of Clinical Surgery, with members going to other members' institutions to witness their anesthetic practice. The oldest member was Lahey Clinic anesthesiologist Lincoln Sise (55 years old); the youngest members were Philadelphian and future first editor of *Anesthesiology* Henry Ruth (30 years old) and Mayo resident Ralph Tovell (28 years old). These young, influential anesthesiologists were those “standing in line” in the McMechan organization or those who believed that McMechan's international vision of the specialty, while important, would not solve domestic issues. The Travel Club would come to dominate the NYSA and become the nidus of leadership for the effort to create the American Board of Anesthesiology (ABA).³⁴

In June 1933, in Milwaukee, Wisconsin, the nurse anesthetists held their first national meeting of the National Association of Nurse Anesthetists. The meeting was notable for a letter of greeting from Everts Graham, MD, then professor of surgery at Washington University in St. Louis and a linchpin in the organization of the ABA some 5 years later. The American Hospital Association was a sponsor of the meeting, and in addition to clinics held at local hospitals, the meeting stressed the importance of a well-organized department of

anesthesiology. It is curious to see many of the same administrative issues that the physician specialists were struggling with were also present at this meeting.²⁶

THE CREATION OF THE AMERICAN BOARD OF ANESTHESIOLOGY

The gains in clinical practice in the 1920s and 1930s are best summed up by Harold Griffith, a leading Canadian physician anesthetist; in 1939, he wrote the following:

Seventeen years ago when I began to give anesthetics, the anesthesia equipment in the small hospital which has ever since been my hospital home, consisted of bottles of ether and chloroform and a few face masks. This was typical of the fairly well-equipped hospitals of that time. Today in that hospital there are eight gas machines of various models, suction equipment in every room, oxygen- and helium-therapy equipment, at least fifteen different anesthetic agents, and much technical equipment for their administration. This transformation has been taking place everywhere in anesthesia.³⁵

Economic reasons played a role in the need to define a specialist in anesthesia because physician anesthetists were not well compensated and faced competition from a number of groups. Surgeons, for example, could hire a nurse to help in the office and give anesthetics, while the surgeon charged a fee for both anesthesia and surgery. The income generated from the anesthetic fee was in excess of what he paid the nurse and therefore profitable. Similarly, hospitals could hire nurses to give anesthetics and make an extra profit. Finally, general practitioners would refer cases to surgeons with the caveat that they could give the anesthetic and collect the anesthetic fee for themselves.³⁶

McMechan proposed the International College of Anesthetists (ICA) and certified the first fellows in 1935, but there were two serious problems with his certification process. First and foremost, the clinical criteria were weak. The applicant only needed to document 10 anesthetic cases to be eligible. In one instance, an intern rotating on the anesthesia service for 1 month wrote up the necessary cases and became certified. In another, a surgeon who only occasionally gave anesthetics successfully completed the necessary paperwork. Certificate in hand, he attempted to become the head of a hospital division of anesthesia. The second issue with the ICA was that it had no standing with the AMA, meaning the certificate was not “official” in the United States.³⁷

Members of the Anaesthetists Travel Club, especially Paul Wood, John Lundy, and Ralph Waters, believed that certification was essential if anesthesiology was going to be recognized as equal to other specialties. Using AMA criteria, which included documentation of either postgraduate training in the specialty or 2500 cases in which the applicant had administered the anesthetic, Wood and his colleagues at the NYSA created a special classification of members called “fellows.” This new form of membership was extremely popular, and the NYSA’s membership skyrocketed. Now national, the society changed its name to the American Society of Anesthetists in February 1936, and in 1945, they were renamed the American Society of Anesthesiologists (ASA).³⁸

Waters, working closely with the chair of surgery at the University of Wisconsin, Erwin Schmidt (**Figure 1-8**), was able to secure an agreement for the ABA to be created as a subboard of the American Board of Surgery. Using AMA criteria, which included the stipulation that the physician must practice the specialty full time, the ABA was created in 1938. The ABA’s first written examination, held in March 1939, was in essay format with five subjects: pharmacology, anatomy, physics and chemistry, pathology, and physiology. There was also an oral examination and a practical at the candidate’s place of practice.³⁹

WORLD WAR II AND BEYOND

The New York World’s Fair opened on April 30, 1939, on the eve of World War II. In the Hall of Man, an anesthesiology exhibit (**Figure 1-9**) allowed the general public to learn more about the specialty. The exhibit



FIGURE 1-8. Erwin Schmidt. [Used with permission from Wood Library-Museum of Anesthesiology.]

was paid for by the Winthrop Chemical Company at a cost equivalent to several million dollars today. This proved that anesthesia had enough of a market impact that industry was willing to spend lavishly to support such a display. Second, the clinical practice of anesthesiology had become both complex and commonplace enough that the lay public would recognize and want to learn about it.⁴⁰

At the same time, Lewis Wright was hired by Squibb Pharmaceuticals to investigate new anesthesia drugs, including curare. Wright was a self-taught anesthesiologist who, in midcareer, took a leave of absence from his job at Squibb and did a residency with Emery Rovenstine at Bellevue Hospital.⁴¹ Wright gave some of the first commercially prepared curare to Rovenstine and Emmanuel Papper. However, Papper felt that the agent was a poor anesthetic, as all the test animals stopped breathing when it was administered to them.⁴² It was Harold Griffith and Enid Johnson, of Montreal, who discovered curare’s true value in anesthesia.⁴³

As the United States plunged into World War II, the anesthesia community was determined not to repeat the mistakes of World War I. Physician anesthetists were in short supply and often ran from unit to unit training corpsmen in ether administration by open drop.⁴⁴ By the early 1940s, anesthesia had become too complex for this to be successful. The leaders of the ASA worked with the armed forces and developed 90-day courses to train medical officers in the basics of anesthesia. These young physicians managed many horrific clinical situations and were able to decrease mortality.⁴⁵ Among these new anesthetists was Samuel Lieberman, who won the Legion of Merit for his work in the South Pacific. By using continuous spinal anesthesia, he decreased the mortality from abdominal wounds from 46% to 12.5%.⁴⁶

Returning from the war, these physicians had tremendous clinical experience, especially with regional anesthesia. Nerve blocks were invaluable because corpsmen could take vital signs and talk to the soldier while the operation was ongoing, freeing the anesthesiologist to treat others. Likewise, these military anesthesiologists had extensive experience with transfusion and fluid therapy. About 40% of them sought additional formal training. Thus, the specialty expanded tremendously, not only because of the returning physicians, but also because their surgeon colleagues demanded physician involvement in anesthesia.⁴⁷

Nurse anesthetists likewise answered the call, creating courses to train nurses as anesthetists. They served with distinction throughout the conflict and would answer the call again and again during all of the US



FIGURE 1-9. Postcard image of the anesthesia exhibit at the 1939 World's Fair. [Used with permission from Wood Library-Museum of Anesthesiology.]

armed conflicts. At the end of World War II, the first qualifying exams for nurse anesthetists were administered. During the 1950s, certification of training programs occurred.²⁶

THE SECOND HALF OF THE 20TH CENTURY

McMechan's vision of an international community of anesthesiologists came to fruition in the 1950s. The first world meeting of anesthesiologists had been scheduled for Paris in the spring of 1940 but was canceled as the German army invaded. By the early 1950s, Europe was starting to recover from the effects of the war, and the original French organizers were still interested in making the meeting a reality. Working within the European community and Canada and with help from the World Health Organization, preliminary meetings were organized and the structure of the World Federation of Societies of Anesthesiologists (WFSA) was created. The first World Congress, held at the Hague in the Netherlands in 1955, was a success despite the absence of the ASA. The WFSA wanted to bring the best clinical practice of the specialty to the forefront, and the World Congress was a way to unite anesthesiologists from all walks of life to discuss problems and seek solutions.⁴⁷

Interestingly, the ASA did not join the WFSA until the late 1950s. This reluctance was multifactorial. First, because WFSA dues were on a per capita basis, the ASA felt that they would be providing the majority of the finances of the organization without an equal voice in its government. There was also hesitancy to join an organization that contained communists. Time, dialogue, and the WFSA's performance eliminated those fears.⁴⁸

Along with the international concerns, the specialty faced a challenge in the United States as well. There was a significant part of the anesthesiology community, from the 1940s on, that felt that no physician should accept a contract for services and allow a third party, such as a hospital or other employer, to bill in the physician's name. This edict was enforced by the ASA through the component societies, for an anesthesiologist could not be a member if he or she was not a component society member. Membership was denied if the prospective anesthesiologist was employed under a contract rather than accepting a fee for service. Furthermore, to be eligible to take the ABA examination, an anesthesiologist had to be an ASA member.⁴⁹ In response to this, the Association of University Anesthesiologists (AUA) was formed. The majority of academic anesthesiologists were employed by the university for a salary, in violation of the ASA edict. The establishment of the organization is important not only as a protest, but also because it underscores how important academics had become to the fledgling field in the 30 years between the creation of the Waters department to the first

AUA meeting.⁵⁰ It was a rapid expansion that continued to delineate the scientific underpinnings of the specialty. The AUA was also the first subspecialty society formed in anesthesiology, and it worked to promote scientific research and teaching.

In the 1960s, the US government created the National Institutes of Health (NIH) to support medical research, and Emmanuel Papper (Figure 1-10) was invited to Washington, D.C., to help organize it. Dr. Papper worked tirelessly to see that anesthesiologists were treated fairly by the NIH and were eligible for funding. However, he was unable to secure an independent study section for anesthesia, and the battle to obtain this for the specialty remains a leading agenda item for many.⁴²

The decade of the 1970s was one of crisis for anesthesiology. To ensure billing that was commensurate with services, the ASA had endorsed a relative value guide that helped place a unit value on work

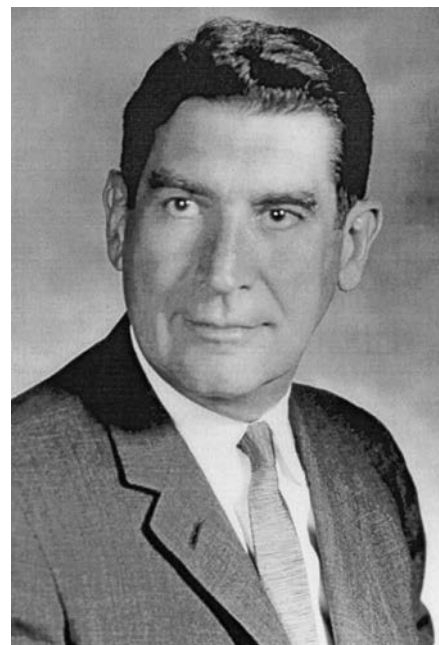


FIGURE 1-10. Emmanuel Papper. [Used with permission from Wood Library-Museum of Anesthesiology.]

done by the physician. Other specialties, including orthopedics and radiology, had adopted similar guides, but the Federal Trade Commission saw this as a monopolistic practice. All other specialties agreed to cease and desist; the ASA instead went to court. After a 2-week trial, the judge ruled that the relative value guide did not represent a monopolistic practice; rather, it was simply a tool that applied monetary value differently in different parts of the country. In one of history's little ironies, 30 years after the verdict, the federal government now considers relative value guides as the preferred billing method. The 1970s also saw another federal government suit against the ASA over fee for service versus an employed model. Thirty years before the legal action, the ASA had adopted a criterion for membership in the 1940s that stated that anesthesiologists would work on a fee-for-service basis similar to internists and surgeons and not as salaried employees of hospitals. In the 1970s, this was viewed by the federal government as restraint of trade, and while there was little chance of a successful suit, both sides agreed to cease and desist, having little desire for another expensive court battle.⁵¹

The 1970s also saw the beginnings of the anesthesiology subspecialty movement. In 1968, discussions and preliminary meetings were held that led to the formation of the Society for Obstetric Anesthesia and Perinatology. Formed in Kansas City in 1969, the group remains diverse, with anesthesiologists, obstetricians, and perinatologists presenting work of common interest.⁵² Likewise in the early 1970s, Maurice Albin and others interested in neuroanesthesia created the Society of Neurosurgical Anesthesia; in 1973, John Mitchenfelder became the first president.⁵³ In 1975, the American Society of Regional Anesthesia (ASRA) was re-formed, although without knowledge of the prior group formed by Gaston Labat in the 1920s. Publishing the first subspecialty journal, *Regional Anesthesia*, the society provided a place for peer-reviewed scholarly publication in regional anesthesia. Coupled with the annual meeting, the society also provided a forum for anesthesiologists interested in pain medicine. Eventually, the society would change its name to the American Society of Regional Anesthesia and Pain Medicine and that of the journal to *Regional Anesthesia and Pain Medicine*, emphasizing the importance of this emerging field.⁵⁴ In the mid-1970s, the Society of Cardiovascular Anesthesiologists emerged, disseminating information about cardiopulmonary bypass and the emerging field of vascular surgery.

The 1980s, by contrast, witnessed the development of two organizations that have served anesthesiology well. The Foundation for Anesthesia Education and Research (FAER) has a special interest in anesthesiologists just beginning their careers and has supported a successful starter grant program. Indeed, many of the leaders of academic anesthesiology in the early 21st century began their careers with a FAER grant. At the same time that the FAER was being formed, the Anesthesia Patient Safety Foundation (APSF) was created to prevent patients from ever being harmed by an anesthetic. The APSF has joined the academic, private practice, and industrial communities to work toward decreasing anesthetic risk. The establishment of the Harvard standards of monitoring, at the beginning of the APSF, was an important step in this direction. The APSF is the model for the patient safety movement across the country and is used by the AMA as a model for its patient safety foundation.⁵⁵

The anesthesiology subspecialty movement continued into the 1980s. In 1987, the first meeting of the Society for Pediatric Anesthesia was held. An outgrowth of the anesthesia section of the American Academy of Pediatrics, the society strove to be inclusive of all anesthesiologists interested in caring for children undergoing anesthesia, not simply anesthesiologists in full-time pediatric practice. Another society formed in the mid-1980s was the Society for Ambulatory Anesthesia.⁵⁶ In response to the growing trend of outpatient surgery, the society strives for the highest standards in anesthesia care in the ambulatory setting.⁵⁷ Likewise, the American Society of Critical Care Anesthesiologists was formed to establish a forum for anesthesiologists interested in the critical care setting.⁵⁸

During the 1990s, the ABA recognized the trend toward subspecialization by creating special qualifications that could be added to board certification in anesthesiology in both critical care and pain medicine.

This trend continues, with added qualifications currently available in palliative care and pediatrics. One of the greatest challenges of modern-day anesthesiology involves the proper role for these additional ABA credentials for general anesthesiologists whose practice also includes the care of children or those in intensive care units or hospices. It remains for practitioners, facilities, the ABA, and the ASA to develop guidelines that support subspecialty care where appropriate without limiting the delivery of anesthesia care in settings where the skills of the general anesthesiologist are commensurate with the challenge (not unlike the challenges in all of medicine relative to primary vs specialty care in the 21st century).

INTRODUCTION OF THE ANESTHESIA ASSISTANT

In the 1960s, yet another shortage of anesthesia providers led to the beginning of the anesthesiology assistant (AA) profession. After studying the educational pathway for anesthesiologists and nurse anesthetists, they created a new educational paradigm for a midlevel anesthesia practitioner that included a premedical background in college. This person would perform the same role as the nurse anesthetists but would be readily able to go on to medical school if appropriate.

The concept became reality in 1969 when the first AA training program began accepting students at Emory University in Atlanta, Georgia, followed shortly thereafter by a second program at Case Western Reserve University in Cleveland, Ohio. Since that time, the number of practicing AAs and their educational programs has grown steadily.⁵⁹

Despite also being midlevel providers with similar job descriptions, AAs differ slightly from nurse anesthetists. Rather than having a nursing educational background, AAs require a science/premedical background that would theoretically allow them to enter medical school more easily than nurse anesthetists if, in the future, they so desired.⁶⁰

CONCLUSIONS

By comparison with most other medical specialties, the history of clinical anesthesia is short. Perhaps Francis Hoeffler McMechan summed it best when in 1935 he wrote the following:

Anesthesia was the gift of pioneer doctors and dentists to suffering humanity, and every significant advance in its science and practice has been contributed by doctors, dentists, and research workers of similar standing. In contrast, technicians have added nothing of any consequence. Anesthetics are among the most potent and dangerous drugs used in the practice of medicine; they penetrate to every cell and organ of the body and may cause almost instant or delayed death by their toxic effects. The dosage of general inhalation anesthetics cannot be prescribed in advance but must be determined from moment to moment during administration. The dosage of local and other anesthetics must be determined by the risk of the patient, the nature and duration of the operation to be done—certainly a challenge to the knowledge and experience of the keenest doctor. No patient should ever be given an anesthetic whose condition and risk has not been diagnosed in advance of the operation, so that every resource of medical science can be used to lessen the risk and make the recovery more assuring. Certainly in this preoperative evaluation and the selection of the safest anesthetic and best method of administration, the medical anesthetist is more in a position to act as a consultant than a technician. . . .

The safety of the patient demands that the anesthetist be able to treat every complication that may arise from the anesthetic itself by the use of methods of treatment that may be indicated. The medical anesthetist can do this, the technician cannot. More recent developments have extended the field of medical anesthesia to include resuscitation, oxygen therapy, and therapeutic nerve block for intractable pain, and treatment of various conditions of disease, and the rehabilitation of the disabled—all fields of practice quite beyond the capacity of the technician."⁶¹

McMechan's vision of professionalism, and its 21st century equivalents, needs to continue to guide the specialty. The history of anesthesia is interesting, filled with fascinating events and people, and is replete with the highest examples of professionalism—the best is yet to come.

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CHAPTER

2

The Scope and Future of Anesthesia Practice

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KEY POINTS

1. The operating room remains the primary focus for the vast majority of practitioners.
2. The practitioner's primary responsibility is to ensure patients' comfort and safety when they are exposed to the trespass of surgery and other invasive procedures.
3. The intraoperative conduct of anesthesia has both immediate and long-term effects on patient safety and outcomes postoperatively.
4. The provision of safe anesthetic care across geographically dispersed sites and encompassing wide ranges of patient health, in an economically responsible manner, is a challenge that anesthesiologists need to address proactively.
5. The personal administration of every anesthetic is not feasible due to workforce limitations; team-based anesthesia care is required to meet the demand for anesthesia services.

6. Meeting the personnel, safety, and cost demands of the future will require that providers overcome the political infighting between organized anesthesiology and nurse anesthesia, especially in an era when the majority of these individual providers work together effectively.
7. Many believe it is important for the future of the specialty that anesthesiologists assume a broader role in perioperative medicine.
8. Advances in knowledge and technology have created an opportunity for anesthesiologists to address the scientific questions at the core of the specialty as well as a variety of important clinical problems.
9. Future opportunities for anesthesiologists include greater involvement in pharmacogenomics, business, and health care systems management and the development of new technologies, while continuing to lead and develop traditional areas, such as operating room anesthesia, critical care, pain medicine, teaching, research, and resuscitation.

Anesthesiology arose as a medical specialty because the dangers associated with anesthetic drugs and techniques demanded administration by skilled and knowledgeable physicians. As safer drugs were developed and physiologic monitoring improved, the need for anesthesiologists was propelled by increasing surgical complexity and severity of patient illness, as well as by increasing expectations for patient safety. Whereas the original *raison d'être* for the specialty remains today, a variety of professional and economic factors have challenged anesthesiology and produced large "swings of fortune" during the past few decades.

During the 1970s and 1980s, the emergence of critical care attracted many talented medical students to American anesthesiology training programs. However, these were halcyon days for anesthesiologists practicing in the operating room, where professional income was high, job opportunities were ample, and increasing surgical complexity demanded an increasing level of medical knowledge and skills. Thus, there was little incentive for anesthesiologists to expand their roles beyond the confines of the operating suites, and many trainees who were initially attracted by critical care subsequently practiced operating room anesthesia only. In contrast, anesthesiologists in Europe and Canada were expanding their roles during this same period in the burgeoning subspecialties of pain, intensive care, and resuscitation.

In the mid-1990s, gloom beset anesthesiology in the United States as predictions, widely reported in lay press such as the *Wall Street Journal*, suggested that the need for anesthesiologists would decrease dramatically in an anticipated managed care environment. Medical graduates were discouraged from pursuing careers in anesthesiology, and residency programs contracted dramatically. But, these predictions were wildly inaccurate. In the last 10 years, US anesthesiology programs have enjoyed a revival, and many talented medical graduates have chosen to enter the specialty.¹ Another encouraging recent trend has been the marked increase in the proportion of US finishing residents who are choosing to pursue fellowships to bolster their specialist knowledge and refine their clinical skills. All of the traditional anesthesiology subspecialties (eg, pain medicine, critical care, pediatrics, clinical scientist) are benefiting from this growing cadre of subspecialists, and new subspecialties are on the rise (eg, sleep medicine and health care administration). Anesthesiologists in other parts of the world have also experienced fluctuating fortunes.

The future of anesthesiology depends on several factors, including changes in surgical and interventional practice, technological advances in anesthesiology, the evolving scope of anesthesia practice, and the role of nonphysicians (eg, nurse anesthetists and anesthesia physician assistants), and physicians trained in other specialties, in the provision of anesthesia care. The evolution of health care financing and the consolidation of private practice groups into large regional and national multispecialty consortia will also continue to influence trends in anesthesia practice. This chapter reviews briefly the current scope of anesthetic practice and offers some possible scenarios for future directions of the specialty.

OPERATING ROOM ANESTHESIA

The operating room remains the primary focus for the vast majority of anesthesiologists. The anesthesiologist's primary responsibility in this arena is to ensure patients' comfort and safety when they are exposed to the trespass of surgery; this includes protecting the patient from pain, undesired awareness, and organ system injury and fostering full recovery from the surgical and anesthetic interventions (not simply the emergence from anesthesia). Over the past decades, it has become increasingly clear that the intraoperative conduct of anesthesia has profound effects on patient safety, surgical outcomes, and comfort in the postoperative period. For example, modest intraoperative hypothermia can either increase the incidence of wound infection² or provide neuroprotection,³ depending on the clinical situation. Some studies have also shown an influence by anesthetic management on broader outcomes,⁴ including surgical mortality⁵ and even recurrence of certain cancers.⁶

Anesthesiologists are increasingly sophisticated in their understanding of patient safety, and they are focusing on such issues as appropriate perioperative medications, antibiotic prophylaxis and infection control, multimodal analgesia, maintenance of normothermia and normoglycemia, and appropriate fluid and electrolyte therapy. A recent observational study demonstrated an almost 2-fold increase in coronary artery bypass graft surgical mortality in "low-performance" anesthesiologists compared to "high-performance" anesthesiologists, highlighting the possible impact that individual providers can have on patient outcomes. A growing responsibility for overall postoperative outcomes raises new expectations for knowledge and skills of the practicing anesthesiologist and challenges our previously narrower definitions of anesthetic outcome.⁷

Despite the demands imposed by increasing severity of illness in surgical patients, growing surgical complexity, and more comprehensive postoperative considerations, anesthesiology is often viewed as a victim of its own perceived success. The widely cited study from the United Kingdom in the 1980s, the Confidential Enquiry Into Perioperative Deaths (CEPOD), reported that patients undergoing general anesthesia have a 1 in 185,000 chance of dying as a consequence of anesthetic misadventure,⁸⁻¹⁰ a finding highlighted in the Institute of Medicine report on medical errors¹¹ that cited anesthesiology as the specialty that had best addressed safety issues (see Chapters 3, 21, and 22 for more comprehensive reviews of quality and safety in anesthesia practice). More recent studies have confirmed low anesthesia-attributable mortality rates in developed countries, ranging from less than 1 in 10:000¹² to 1 in 40,000 or 1 in 120,000 cases.¹³ However, developing countries continue to have mortality rates that are an order of magnitude greater (141 events per million anesthetics in developing countries vs 25 events per million in developed countries).¹⁴ Despite the accepted improvements in perioperative mortality, the exact rate may be greater than recently reported. Further, the reported mortality rates vary significantly due to differences in definitions and reporting sources.¹⁵

As a result of the major improvements in anesthesia-attributable mortality over the last several decades, the perception of anesthesia as "safe" has encouraged nonphysician anesthesia clinicians to advocate for independent practice, with over a dozen US states choosing to opt out of mandatory physician supervision. It has also suggested to insurers that anesthesia care by a physician anesthesiologist is needlessly expensive. While some studies have suggested that rates of mortality associated with anesthesia are actually higher than those publicized,¹⁵ the fact remains that the field has made significant strides in reducing these rates. However, as Ronald Miller warned in his 2009 Rovenstine lecture, anesthesiologists cannot "content ourselves with the fact that few patients experience intraoperative death due solely to anesthetic mishap."¹⁶ Overall surgical mortality remains as high as 4% in the week following surgery,¹⁷ and almost 40% of in-hospital adverse events are related to surgical operations.¹⁸ Many problems in perioperative safety remain to be addressed, and anesthesiologists must be willing to share responsibility with our surgical colleagues for a broader range of outcomes to truly be co-equal partners in the evolution of twenty-first-century health care systems.¹⁹

Challenges to anesthesiology are exacerbated by the massive expansion in demand for anesthesia services for a variety of nonoperative procedures, ranging from cerebral aneurysm coiling to pediatric sedation for procedures²⁰ and general anesthesia for screening colonoscopy.

The introduction of free-standing ambulatory surgery centers and office-based surgical suites where anesthesia is administered raises other concerns. The demands for safe anesthesia care provided in numerous remote locations with a wide range of severity of patient illnesses present significant challenges to the workforce, financing, and practice of anesthesiology that anesthesiologists need to address proactively.

Current practice models vary widely in both the United States and worldwide. In the United States, some anesthesiologists (or practice groups) personally provide all anesthetic care regardless of complexity, an approach that is also common in the United Kingdom, Canada, and Australia. In other practices, anesthesiologists supervise other clinicians (eg, nurse anesthetists, residents, or anesthesia assistants) in more than one operating room, a practice model found in many European countries, including the Netherlands, France, Denmark, Switzerland, and Norway. Currently, at least 50% of anesthesia care in the United States involves nurse anesthetists, and anesthesia practice worldwide often includes some form of nonphysician clinician or physician who is not a fully trained anesthesiologist. Some reports asserted that nonanesthesiologists can safely provide anesthesia for selected procedures (eg, colonoscopy) and patients,²¹ and that nurse anesthetists perform no worse than trained anesthesiologists in simulated patient emergencies²² (see Chapter 21 for an in-depth discussion of risk in anesthesia, including an assessment of the validity of several of the practice pattern comparisons). It is also clear that patients with minimal physiological reserve, those undergoing major interventions, and those with complex medical problems likely require the direct involvement of a skilled anesthesiologist to enhance patient safety.^{23,24} Unfortunately, too often practitioner skill and experience are not matched to these factors but determined by availability of clinicians or the use of a fixed model of care delivery, rather than one that is tailored to the specific clinical situation. This is a fruitful area for further health services research by anesthesiologists to ensure proper matching of resources to the clinical needs.

The expectations for operating room anesthesia can be simply stated: *We need to provide an ever-increasing quality of perioperative care at a lower cost.* In turn, these expectations and predictions require that the anesthesiology community consider who will, or should, provide each component of anesthesia care; what levels of knowledge and skill will be required of each clinician; and how the responsibility for care will be organized, managed, and rewarded. It is arithmetically impossible to provide a fully trained individual anesthesiologist for every anesthetic procedure.²⁵ Further, the increasing demands for anesthesia services (aging population, proliferation of ambulatory surgery centers, escalating demand for nonsurgical anesthesia and sedation) will outstrip even the most aggressive output of anesthesiologists. Medical schools simply would not have the capacity to provide sufficient graduates to populate a large increase in the number of anesthesiology residents, and the current economic environment does not have the resources to sustain such an expansion.

For reasons of both anesthesiologist availability and cost, it is thus apparent that the future of anesthesia practice will involve an increasing role for nonphysician clinicians. How can this be made compatible with the demands for increasing safety and quality? This can be accomplished by involving skilled anesthesiologists in the cognitive aspects of every anesthetic. This will require coordination and cooperation with nonphysician clinicians, allowing them to perform at the highest levels compatible with their training, knowledge, and experience, while ensuring that a fully trained specialist is involved in planning and managing care for high-risk cases and is readily available for complex diagnostic and therapeutic decision-making.

Technological developments in monitoring and information systems should facilitate these changes. The development and expansion of telemedicine in critical care units, and the demonstration of resulting improved patient outcomes,²⁶⁻²⁸ provide one model of care that could be feasible even in communities where an anesthesiologist is not physically present.²⁹

Meeting the personnel, safety, and cost demands of the future will require that providers overcome the political infighting between organized anesthesiology and nurse anesthesia, especially in an era when the majority of these individual providers work together effectively. Further,

the training of anesthesiologists will increasingly need to encompass the development of skills in managing team-based care when working with other anesthesia clinicians. It is in the interests of public safety and health care delivery that unity be forged among anesthesia clinicians under the leadership of specialist anesthesiologists, whose medical training and education are required for complex medical decision-making, supplemented by the skills and abilities of nonphysician clinicians who further enhance this team approach.

OUTSIDE THE OPERATING ROOM

PREOPERATIVE CARE

Perioperative morbidity is frequently attributable to poor preoperative patient assessment and preparation. These roles have always been integral to the anesthesiologist's practice. However, as patients increasingly present to the hospital on the day of service, it has become necessary to ensure that patients are properly evaluated well before the immediate preoperative interval. Recognizing this need has led to burgeoning preoperative assessment clinics, where problems such as ischemic heart disease, pulmonary disease, or sleep apnea may be evaluated and appropriate perioperative interventions may be planned (see Chapter 5 for a detailed discussion of the benefits and operation of preoperative clinics). In some practice settings, preoperative assessment of complicated patients has been largely relegated to nonanesthesiology trained physicians or physician extenders. In other settings, the challenge of same-day surgery admission has left preoperative assessment as a day-of-surgery activity; neither of these approaches is uniformly optimal. Almost all models for the future practice of anesthesia include greater involvement of anesthesiologists in the continuum of patient care and thus a greater role in patient outcomes. From this standpoint, it is essential that anesthesiologists continue to play an integral role in preoperative assessment clinics. This should also be a key component of anesthesia resident training programs, for it represents an important aspect of patient safety and the future anesthesia practice.

PAIN MEDICINE

Doctors cannot always cure disease, but they should always try to alleviate suffering. Physical pain is among the most unpleasant of human experiences. Anesthesiologists are often involved in the management of severe pain associated with surgery, and the perioperative use of analgesics constitutes an important component of anesthetic care. Anesthesiologists are more comfortable with opiate administration than many other physicians, because of both their knowledge of pharmacology (especially opioid pharmacology) and their skill and experience in managing side effects, such as respiratory depression. Anesthesiologists have pioneered regional anesthetic techniques, many of which are applicable to the treatment of chronic intractable pain. Increasing numbers of anesthesiologists are specializing in pain management, and the effective relief of pain will remain an important component of the anesthesiologist's role even for those who do not subspecialize specifically in pain medicine.

CRITICAL CARE MEDICINE

Anesthesiologists pioneered the development of critical care medicine,³⁰ and in many countries outside the United States, anesthesiologists constitute the bulk of the physician workforce in critical care. In most of Europe, full training in critical care is an integral component of an anesthesia residency, and critical care anesthesiologists are responsible for organizing and staffing most hospital critical care units. In contrast, US anesthesia residents receive only a few months of critical care training, and anesthesiologists constitute a minority of the nation's critical care physicians. Many believe that part of the future of the specialty will be an increased commitment of anesthesiologists to critical care medicine. To achieve this, leading academic programs must expand their critical care fellowships and promote critical care as a financially viable and intellectually rewarding subspecialty for talented graduating residents.

CLINICAL SERVICES ADMINISTRATION

The operating suite is a complex environment, one that often has not been efficiently managed. Anesthesiologists are an integral component of this important but unwieldy organization. The need for effective management and administration is being increasingly recognized, and anesthesiologists are often sought for this management function. In many countries, including in Europe and North America, anesthesiologists are acquiring formal training in health care management and business administration. Today's doctors, even in academic institutions and national health services, cannot afford to isolate themselves from the realities of reimbursement, cost, efficiency, patient satisfaction, and overall system performance, and there appears to be a bright future for physician leaders in health care organizations. Anesthesiologists are, and will continue to be, an important part of this management evolution.

PATIENT SAFETY

Anesthesiologists have been at the forefront of pioneering patient safety. The improvements have been so dramatic that liability insurance for anesthesia practice continues to decrease while that for most other specialties has steadily increased (some dramatically). The Anesthesia Patient Safety Foundation (APSF) was founded in the United States in 1984 with the expressed purpose of ensuring "that no patient shall be harmed by the effects of anesthesia." Since 1985, the Committee on Professional Liability of the American Society of Anesthesiologists (ASA) has been studying records of closed malpractice claim files for anesthesia-related patient injuries.³¹ Over 10,000 claims have been studied. Similar safety foundations and incident review boards have been established in many other countries; in 1987, the Australian Patient Safety Foundation was established,³² and the national CEPOD was started in the United Kingdom in 1989. Analysis of critical incidents has reinforced the value of physiologic monitoring in improving patient safety. The results also confirmed the value of structured algorithms in anesthesia care by documenting favorable outcomes in a range of life-threatening crises during anesthesia. Changes in consultant practice, increased medical audits, appropriate matching of specialist experience to patients' medical conditions, and increased awareness of the need for critical care services have all been affected through these inquiries.³³

Critical events occur within the context of complex system failures, and anesthesiologists have developed safeguards to decrease the likelihood that human error may result in patient harm. Examples include audible alarm settings and automated anesthesia machine checks, the pin index safety system, and written "checklists." A seminal study showed how the routine implementation in hospitals around the world of a simple 19-item surgical safety checklist designed to improve team communication and consistency of care markedly reduced 30-day complications (from 11% to 7%) and deaths (from 1.5% to 0.8%) associated with surgery.³⁴ Expertise in patient safety should be developed and translated into the broader medical context, including application in areas not historically viewed as the purview of anesthesia practice (such as diagnostic and treatment suites, obstetrical suites, intensive care units, and intermediate care units).

RESEARCH

Anesthesiology has a vibrant history of research and intellectual contributions to clinical medicine. Historically, anesthesia research has focused on laboratory investigations in physiology and pharmacology and their application to patient care. These contributions have improved the safety of anesthesia and surgery and constituted pioneering efforts in the initial application of scientific principles to individual patient care. Previously, many of the scientific questions at the core of anesthesiology were relatively inaccessible to investigation; this stemmed from the absence of tools to study the mechanisms of the complex behaviors (eg, consciousness, memory, pain) that anesthesiologists manipulate. Advances in cellular physiology, molecular biology, genetics, functional imaging, and behavioral sciences, and the application of advanced statistical and mathematical models, have enabled serious investigation of