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# Anesthesiology

SECOND EDITION




DAVID E. LONGNECKER

DAVID L. BROWN

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Mc Graw Hill

# Anesthesiology

## NOTICE

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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 two dominant trends. First, the passage of the Patient Protection and Affordable Care Act (PPACA) of 2010 codified the US commitment to broad-based access to health care, and it underscored that such care must be more efficient and cost effective. Second, the emphasis on quality and safety in health care has gained even greater momentum. Together, these trends emphasize the concept of value in health care. These trends are not unique to the United States. Rather, they represent global trends in health care policy and practice. We believe they will be dominant themes for many years to come and thus they are guiding principles in the second 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 should not be leaders in efficiency and value 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) published its landmark analysis of American health care, "To Err is Human," a treatise that emphasized the fallibility of even highly motivated humans, and emphasized 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. A subsequent 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 medicine and anesthesiology. Further, we have designed this text around the concepts of safe, effective, efficient, and patient-centered care, and we urge others 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 have focused 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?" Our goal was to write for practitioners, not physician scientists. That said, this is not a users' manual of anesthesia care, but rather a text that constantly builds on the concepts of safe, effective (ie, evidence-based), efficient, and patient-centered care, distilled in a manner that facilitates easy access to the key scientific concepts that underpin the rationale for that 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, including especially perioperative medicine, critical care medicine, and pain medicine, each of which improves patient care and enhances the value of anesthesia care within the overall health care process. We have emphasized important trends in both 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 the expanded use of regional anesthesia, 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 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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# PART 1

# The Specialty of Anesthesiology

CHAPTER 1

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

Douglas R. Bacon

## KEY POINTS

1. The history of anesthesiology is an interesting and complicated story of professionals seeking to understand the anesthetic state and to anesthetize patients safely.
2. Shortly after the first public demonstration of ether anesthesia on October 16, 1846, the news spread across the world. At first anesthetics were given based on written accounts, often in the lay press.
3. John Snow, a London physician, worked out the physics of vaporization of volatile agents by observation off 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 in 1905. The Long Island Society eventually became the American Society of Anesthesiologists.
5. Francis Hoffer McMechan organized professional anesthesia. He helped create the first national organization, the Associated Anesthetists of America in 1912, 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 Water is credited with the first department of anesthesia within an academic setting at the University of Wisconsin in 1927. Much of the current residency structure comes from this seminal department that helped establish the specialty on an equal footing with other medical specialties and created a method to train physicians in the art and science of anesthesia.
7. John Lundy, working 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, by 1938, the American Board of Anesthesiology, which defined what it meant to be an anesthesiologist in the United States.
8. The need for physician specialists in World War II exposed a large number of young men to anesthesiology who would not have otherwise considered the specialty. After the hostilities ceased, these physicians returned and helped create the tremendous growth in the 1950s and 1960s that the specialty enjoyed.
9. In the mid-1950s, the World Federation of Societies of Anesthesiologists (WFSA) was formed. It was the culmination of a dream that dated to the late 1930s. The WFSA made it possible for nations with a long tradition of physician specialization in anesthesia to help train and create the specialty in countries where it did not or does not exist.
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 throughout the history of anesthesiology. These two organizations work to create a safe anesthetic environment. In addition, they support educational and research efforts in the specialty.

The quest for insensibility to the surgeon's knife is a primordial one. Stretching back to antiquity, physicians have sought ways to render a patient pain free while an operation was being performed. Many different regimens were tried, with varying success, until October 16, 1846, when surgical anesthesia was publicly demonstrated at the Massachusetts General Hospital by William Thomas Green Morton. Yet there remained a long road from that fall day in Boston 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 the men and women 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. Yet each individual was a real human, many displaying professionalism beyond what was required or expected; others seem reprehensible by "modern" standards. Although many of the individuals in this story would not consider themselves specialists in anesthesia, their contributions were critical in moving the specialty forward. The development of anesthesiology can be told as the history of involved physicians who dedicated themselves to providing safer, 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 between 3000 and 2500 BC. Although there is no specific anesthetic agent, within the papyrus there is evidence of compression anesthesia. In one instance, a surgeon is compressing the antecubital fossa while operating on the hand; in another instance, the patient is compressing 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 India[3] long before Western medicine developed crude forms of anesthesia.

During the Middle Ages and early Renaissance, a mixture of herbs purported to induce anesthesia was created. Boiled into a sponge, 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, with the incision placed between them. This was effective for simple operations and found use in the Russo-Finnish War of 1939-1940.[4] Alcohol, when drunk in sufficient quantities, was noted to render individuals insensible. Thus the age-old intoxicant was used as a standard against which all anesthetics could be measured.[3]

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

Two months later, in rural Georgia, a country doctor, Crawford Long, who had hosted parties where ether was used as an intoxicant, used the drug to render James Venable insensitive for the removal of tumors from the back of his neck. Long charged Venable $2 for the anesthetic, thus delineating anesthesia as part of a physician's professional service.

Two years later, in 1844, Horace Wells, a dentist in Hartford, Connecticut, would gain the insight that, during a nitrous oxide ($N_2O$) show, when an individual was intoxicated by $N_2O$, pain was abolished. Wells then tried this idea on himself for the removal of one of his teeth by his partner, and it was successful. Soon he was using "painless dentistry" as part of his professional advertisement. Wells even attempted to demonstrate a painless tooth extraction at the Massachusetts General Hospital in 1844, but the patient groaned, although later had no memory of the event, and the demonstration was considered a failure.[7]

Clearly, by the middle of the 19th century, there were sufficient observations about specific agents that could potentially abolish the pain of surgery. On a limited scale in rural Jefferson, Georgia, surgery with ether anesthesia was happening. Yet Long felt he lacked sufficient cases to study the effects of this new agent.[8] Wells's use of $N_2O$ was groundbreaking, yet he lacked the emotional stability to overcome his failed demonstration.[9] Thus the stage was set for another dentist to demonstrate reproducible surgical anesthesia and give birth to what would grow and develop into the specialty of anesthesiology.

## DISCOVERY

On October 16, 1846, William Thomas Green Morton, a dentist and medical student, provided surgical anesthesia for Gilbert Abbott for the removal of a tumor of the jaw at Massachusetts General Hospital. The events of that day are well known.[10] Upon completing the operation, the 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 these letters arrived, where they arrived, and who provided anesthesia first in the new location. For example, 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 by which ether was administered, so writing to the foremost patent attorney in England to secure rights to the administration of ether in the United States and the United Kingdom,[9] and perhaps the world, is not surprising. He also tried to patent ether itself, calling his anesthetizing mixture "Letheon." However, the distinctive odor of ether gave away the true nature of the concoction. The Boston medical establishment had convinced Morton to allow Massachusetts General Hospital to use Letheon without charge. With ether a well-known and easy-to-synthesize compound, and its effects reproducible without the "Morton's Inhaler," the patent was unenforceable. Morton would spend the rest of his life attempting to be compensated for patent infringement, fighting with the medical establishment and into the halls of Congress.[8] Morton clearly was not the embodiment of medical professionalism as we currently understand it.

News of Morton's achievement did travel, and quickly, given the nature of communication in the 1840s. On December 16, 1846, ether anesthesia, in the form of a letter, arrived in London. On December 19, the first ether anesthetic was given in the United Kingdom for the removal of a tooth. On December 21, Robert Liston, the famous surgeon, amputated the leg of a butler and uttered the famous words, "This Yankee dodge beats mesmerism hollow." By early 1847, anesthetics were being given across Europe. In June of that year, the news had spread to Australia.[12] Peter Parker, minister and physician missionary in China, gave the first anesthetics there on October 4, 1847.[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 of Boston, none of the recipients 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 of these medical professionals, their desperation at their inability to alleviate pain, and their desire to help patients may well have motivated them to try this new technique. Yet when viewed from the perspective of current 21st-century medical practice, this willingness to go on purely written accounts, often in the lay press, without the collaborating voices of the medical profession, seems to be dangerous and without regard for the basic principle of medicine: first do no harm.

And what of the surgeons? Tolerance of the pain of surgery 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 physician responsible for the patient, long before the specialty of anesthesiology would be defined, why were these professionals willing to risk lives to find an anesthetic? What does this behavior 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," he was acting within the ethics of his time. The American Medical Association (AMA) was only just beginning to be formed. Meeting for the first time in May 1846, 5 months before the public demonstration, the National Medical Convention adopted a resolution to write a code of medical ethics. A 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 when Morton was trying to patent either ether or the apparatus for its vaporization, medicine was starting to organize and promulgate statements against such behavior.

In contrast, John Snow (**Fig. 1-1**), a London physician, began to study the chemical and physical properties of ether, and by 1847 he had

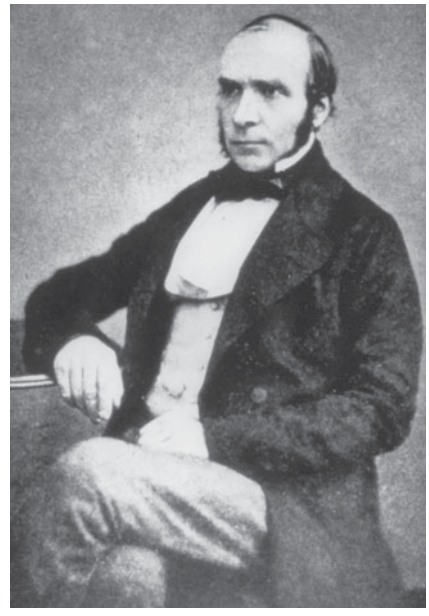

**FIGURE 1-1.** John Snow. [Photograph courtesy of the Wood Library-Museum of Anesthesiology.]

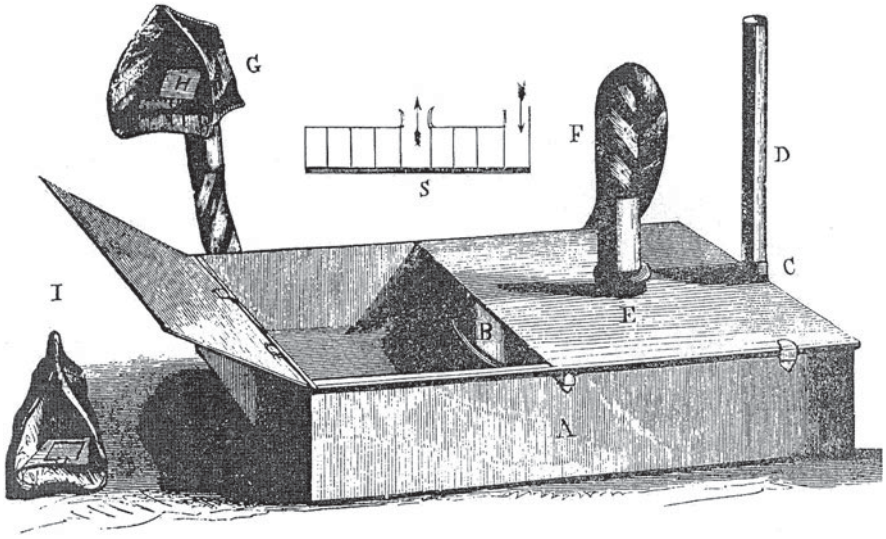


**FIGURE 1-2.** Snow's vaporizer. [Image courtesy of the Wood Library-Museum of Anesthesiology.]

developed a vaporizer. "Snow never patented any apparatus he designed. On the contrary, he published clear descriptions, including engraved figures, so that others could copy them if they chose."[15] Snow, by careful observation, worked out the vaporization characteristics of ether. His vaporizer (**Fig. 1-2**) was temperature compensated, being made of coiled copper (**Fig. 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 required for anesthesia 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 began to investigate this second anesthetic agent. Snow used his experience with ether as a guide for investigating the properties of chloroform. He concluded that it was far safer to give this new anesthetic in measured quantities through an inhaler and did not favor 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. His deliberate nature and strong powers of observation allowed Snow to create a calibrated, temperature-compensated vaporizer for chloroform as well.[13]

Snow was unique among his colleagues in the 1850s in London. 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, a status he could not have obtained had he not limited his practice. Perhaps this is best illustrated by his attendance on Queen Victoria for the birth of her last two children. Although Snow did not use his inhaler, he also did not induce the full anesthetic state in the queen. Rather, he strove for analgesia with chloroform, and in so doing, he created a form of obstetric analgesia, *chloroform à la reine*, which would persist in various forms over the next century.[13]

Aside from working out the physics of vaporization, Snow was intensely interested in outcome data. He studied every report concerning a death under anesthesia and oftentimes had data in advance of the published reports of death. He commented extensively on the death of Hannah Greener, 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. Snow's spirit of inquiry, which went from the bench top to the pathologic findings at death, helped him understand the nature of the anesthetic process and the agents that produced insensibility, thus the scientific underpinnings for a specialty.[18]

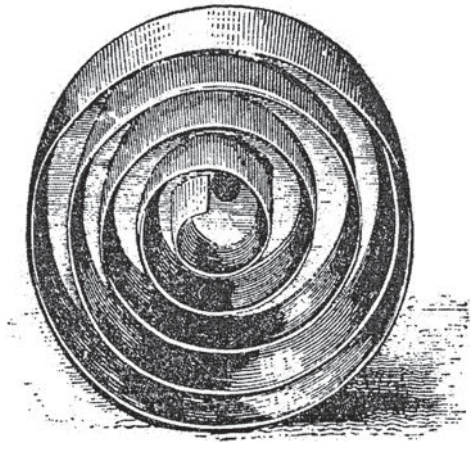

**FIGURE 1-3.** Coil from Snow's vaporizer. [Image courtesy of the Wood Library-Museum of Anesthesiology.]

## A PROFESSION EMERGES

After Snow's untimely death, anesthesia faded into the medical background again. In larger cities, there were those who made most 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 deaths that seemed unexplainable. Ether appeared to be safer, yet the side effects of nausea and vomiting, and the prolonged induction when compared with chloroform, made ether a less-than-ideal agent. Surgeons began to search for alternative methods for the administration of anesthetics.

In 1884, Carl Koller, a resident in ophthalmology in Vienna, was introduced by Sigmund Freud to a new crystalline substance called cocaine. Koller sought a local anesthetic to replace ether anesthesia for operations on the eye; because fine suture material to close the eye wound did not exist, any postoperative retching potentially could cause the loss of vision. Thus 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 on the eye. Using the facilities of the laboratory in which he worked, Koller soon 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. Too poor to travel, his colleague, Dr Josef Brettauer, presented the paper for Koller.[19]

While Koller continued his career in ophthalmology, eventually emigrating 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 the work he did on himself, becoming addicted to cocaine in the process.[20] Another of the pioneers of regional anesthesia was the German surgeon Carl Ludwig Schleich, who developed the technique of infiltration anesthesia.[21] Combining infiltration techniques with the newly discovered lumbar puncture, August Bier, another academic German surgeon, 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 that is still referred to as the Bier block.[23]

At the same time when regional anesthesia was being developed in Germany, concern over the safety of chloroform, especially when compared with ether, was developing. In India, then a colony of England, a Chloroform Commission was seated in Hyderabad to attempt to determine which anesthetic agent was safest. Funded by the Nizam of Hyderabad, the 1888 study of anesthetic agents was an effort to find out if there was an intrinsic mortality associated with chloroform. The findings were tainted by the British medical officer in charge, Dr Edward Lawrie, who was a strong chloroform proponent, having trained in Edinburgh, chloroform's birthplace. The findings of the Hyderabad Chloroform Commission were not conclusive, and a second was ordered, which also was inconclusive. But what was important in these commissions is that physicians were studying anesthesia and trying to increase patient safety. For many physicians, the need for a specialty practice of anesthesia was slowly becoming apparent.[24]

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

> [A]ll 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 very interesting recommendations:

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

The third suggestion of the commission would take almost the entire 20th century to implement.

## THE RISE OF THE SPECIALIST

In 1905 in Brooklyn, New York, a group of 8 physicians and a medical student, led by Adolph Frederick Erdmann (**Fig. 1-4**), gathered to discuss

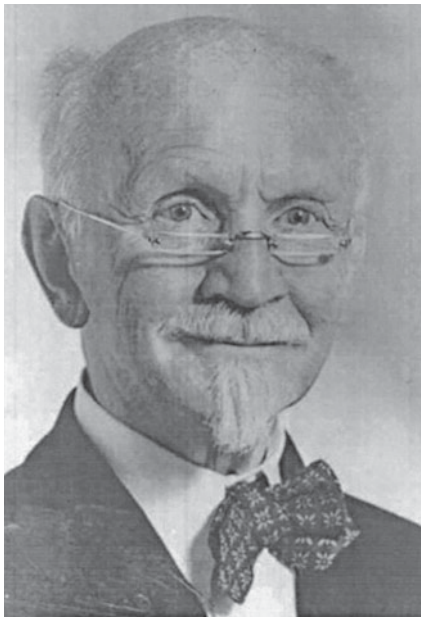

**FIGURE 1-4.** Adolph Frederick Erdmann. [Photograph courtesy of the Wood Library-Museum of Anesthesiology.]

the problem of anesthetics. These young physicians thought, like the AMA commission, that there was more to the giving of an anesthetic than simply dropping ether on a cloth held near the patient's face, and that discussions and a free exchange of scientific and practical information were needed.[26] This was the second specialty group in the world that was created. The first was the London Society of Anesthetists in 1893, and it would become the catalyst for the development and recognition of physicians who were specialists in anesthesia.[27] Thus the Long Island Society of Anesthetists was born. The society met quarterly, in the evening, with a short business meeting followed by the presentation of 2 or 3 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 at which to exchange ideas and deal with problems beyond the science of anesthesia.[26]

The group flourished and, in 1912, moved across the river to New York City, changed the organization's name, and became the New York Society of Anesthetists. Over the next 24 years, the society would grow, both in membership and in scope. Starting out as a New York City group, by the mid-1920s, the group encompassed all of the state. By 1936 it had become a national organization.[28] The transformation focused on the recognition of physicians who primarily anesthetized patients as specialists.

The first significant political move of the New York Society was a motion put before the House of Delegates of the AMA asking for a Section on Anesthetics in 1912. The members of the society were concerned about nonphysicians giving anesthetics, and they echoed some of the findings of the AMA's Commission on Anesthetics some 6 years earlier.[28] James Gwathmey (**Fig. 1-5**), 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 very familiar with its use and with the effects of anesthesia in general.[29] 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 latter half of the 20th century.

The motion was denied by the AMA House of Delegates. However, Gwathmey and Francis Hoeffer McMechan (**Fig. 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 who met the following year, 1913, for

**FIGURE 1-5.** James Tayloe Gwathmey. [Photograph courtesy of the Wood Library-Museum of Anesthesiology.]

a day of papers, mostly clinical in origin, and a dinner, with spouses (**Fig. 1-7**). A day devoted to the science of anesthesia is memorable; the evening meal signified a group, however small, that was willing to be recognized as specialists in anesthetics and by uniting, to move the field forward.[28]

The AAA, and its successor, the Associated Anesthetists of the United States and Canada, were run by Francis Hoeffer McMechan. A third-generation physician who entered anesthesia against the advice of his physician father, McMechan had crippling rheumatoid arthritis and was out of clinical practice by 1911. He was a visionary who hoped to see, on a worldwide scale, the elevation of anesthesia to "stand shoulder to shoulder" with surgery and internal medicine. 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. Convincing his friend Joseph McDonald, the editor of the *American Journal of Surgery,*

**FIGURE 1-6.** Francis Hoeffer McMechan. [Photograph courtesy of the Wood Library-Museum of Anesthesiology.]

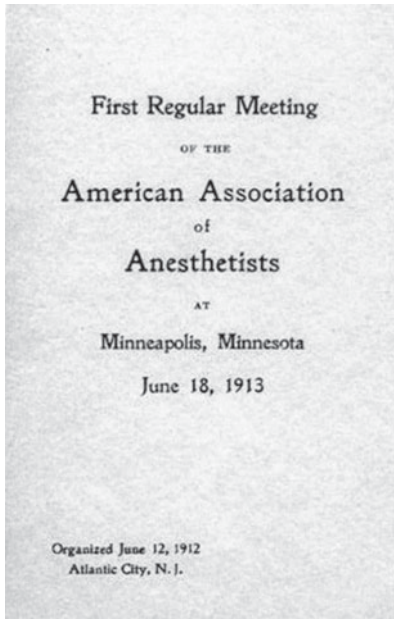


**FIGURE 1-7.** Program of the first meeting of the American Association of Anesthetists, June 18, 1913, Minneapolis, Minnesota. [Image courtesy of the Wood Library-Museum of Anesthesiology.]

to publish a supplement on anesthesia gave the physician specialty its first US quarterly. McMechan also edited the *Yearbook of Anesthesia* between 1914 and 1919, compiling all the papers published in the specialty in the preceding year into a single volume.[30]

McMechan also understood that the specialty would never develop as a discipline within medicine without a strong scientific underpinning. To that end, first nationally, and internationally in the mid-1920s, McMechan organized a society devoted to research in anesthesia. The International Anesthesia Research Society (IARS) brought together basic science researchers and the physicians most in need of their talents. Most importantly, the IARS sponsored the first journal in the world devoted to anesthesiology, *Current Researches in Anesthesia and Analgesia*.[31]

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 the medical school transformed itself from a 2-year institution offering only basic science education into a 4-year curriculum with all the 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 the basic science researchers, at first on problems of carbon dioxide absorbance, and later, through various members of his department, on all aspects of anesthesiology. Perhaps most importantly, Waters established the first residency training program in an academic center. The training was 3 years beyond the intern experience. Years 1 and 3 were clinical, with year 2 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 the current literature in anesthesia. 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 across the country.[32]

In 1929, the year of the stock market crash and the beginnings of the Great Depression, another pivotal event occurred in anesthesiology. The Anaesthetists Travel Club was organized by John Lundy at the Mayo Clinic. The group was created along the lines of the Society of Clinical Surgery, with members going to other members' institutions to see their anesthetic practice in action. It was a young man's group, with the oldest member Lahey Clinic anesthesiologist Lincoln Sise at 55 years of age and the youngest the Philadelphian and future first editor of *Anesthesiology* Henry Ruth at 30 years of age, and Mayo resident Ralph Tovell at 28 years of age. The average age was just 40 years. 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, although important, would not solve domestic issues. The Travel Club would come to dominate the New York Society and become the nidus of leadership for the effort to create the American Board of Anesthesiology.[33]

## THE CREATION OF THE AMERICAN BOARD OF ANESTHESIOLOGY

Once there was an organization in place to address national issues, regular meetings of a society devoted to the specialty, a university presence, ongoing research into clinical problems, and a residency training program to continue to retain and transmit the knowledge already gained, some recognition of a physician practicing the specialty was important. The gains in clinical practice in the 1920s and 1930s are best summed up by Harold Griffith, a leading Canadian physician-anesthetist of the time when he wrote, in 1939, 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.[34]

Economic reasons played a role in the need to define a specialist in anesthesia, for 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. The surgeon could then charge each patient a fee for anesthesia in addition to the fee for surgery. The income generated from the anesthetic fee was in excess of what he paid the nurse, and thus profitable. Likewise, hospitals could hire nurses to give anesthetics, charge a fee that cumulatively was in excess of the salaries, and make a profit. Finally, general practitioners would refer cases to surgeons with the caveat that they could give the anesthetic and collect the anesthetic fee.[35]

McMechan proposed an International College of Anesthetists and certified the first fellows in 1935. There were two serious problems with his certification process. First, and foremost, the clinical criteria were weak. The applicant only had to document 10 anesthetic cases, with lessons learned, to be eligible. In one instance, an intern on the anesthesia service for 1 month wrote up the necessary cases and was certified. In another, a surgeon who occasionally gave an anesthetic completed the necessary paperwork and was certified. With certificate in hand, he attempted to become the head of a hospital division of anesthesia. Second, the college had no standing with the AMA, and the certificate meant nothing "official" in the United States.[36]

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 an equal with all other specialty practices. Using AMA criteria, which included documentation of either postgraduate training in the specialty, or 2500 cases where the applicant had administered the anesthetic, Wood and his colleagues at the New York Society created a special classification of members called "fellows." This new form of membership was extremely popular, and the membership of the New York Society skyrocketed. Now national in membership, the society changed its name to the American Society of Anesthetists in February of 1936.[37] In 1945 the American Society of Anesthetists became the American Society of Anesthesiologists (ASA).

**FIGURE 1-8.** Erwin Schmidt. [Photograph courtesy of University of Wisconsin Archive Collection, Madison, Wisconsin.]

The AMA took note largely through Lundy's efforts, and Waters, working closely with Erwin Schmidt (**Fig. 1-8**), the chair of surgery at the University of Wisconsin, was able to secure an agreement for the American Board of Anesthesiology (ABA) to be created as a subboard of the American Board of Surgery. Using AMA criteria, which included, in addition to the heavy clinical training, the stipulation that the physician had to be in full-time practice of the specialty, the ABA was created in 1938. The first written examination of the ABA was held in March 1939. It was an essay format, with 5 subject subheadings: pharmacology, anatomy, physics and chemistry, pathology, and physiology. There was an oral examination and a practical one at the candidate's place of practice.[38]

## WORLD WAR II AND BEYOND

The New York World's Fair opened on April 30, 1939, the eve of World War II. In the Hall of Man, an anesthesiology exhibit (**Fig. 1-9**) allowed the general public to learn more about the specialty. The exhibit was paid for by the Winthrope Chemical Company at a cost equivalent to several million dollars today. This is important for two reasons: First, it demonstrated 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.[39]

At the same time, Lewis Wright was hired by Squibb Pharmaceuticals to investigate new anesthesia drugs, among them 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.[40] It was to Rovenstine and Emmanuel Papper that he gave some of the first commercially prepared curare. Papper felt that the agent was a poor anesthetic because all the test animals stopped breathing when it was administered to them.[41] It was Harold Griffith and Enid Johnson, of Montreal, who discovered the true value of curare in anesthesia.[42]

As the United States plunged into World War II, the anesthesia community was determined not to repeat the mistakes of World War I.


**FIGURE 1-9.** Postcard image of the anesthesia exhibit at the 1939 World's Fair. [Image courtesy of the Wood Library-Museum of Anesthesiology.]

Physician anesthetists had been in short supply and often ran from unit to unit training corpsmen in the administration of ether by open drop.[43] By the early 1940s, anesthesia had become too complex for this to be successful. The leaders of the ASA worked with the advisers to the armed forces and developed short 90-day courses to train medical officers in the basics of anesthesia. These young physicians managed many horrific clinical situations and, applying what they learned, were able to decrease mortality.[44] The case of Samuel Lieberman, who won the Legion of Merit for his work in the South Pacific, is illustrative. By using continuous spinal anesthesia, he decreased the mortality from abdominal wounds from 46% to 12.5%.[45]

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. These military anesthesiologists had extensive experience with transfusion and fluid therapy. Returning to the United States, approximately 40% sought additional formal training. Thus the specialty expanded tremendously, not only because of the returning physicians, but also because surgeons exposed to the field work of the anesthesiologists demanded physician involvement in anesthesia.[44]

## 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 took the city. By the early 1950s, Europe was starting to recover from the effects of the war and the original French organizers were still interested in seeing the meeting become a reality. Working within the European community and Canada, and with help from the World Heath 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 fore; the World Congress was a way to bring first-, second-, and third-world anesthesiologists together to discuss problems and to seek solutions. The WFSA set up programs to share information with those in need of it.[46]

However, it would not be until the end of the 1950s that the ASA would join the WFSA. The reluctance on the part of the Americans was multifactorial. First, because dues to the WFSA were on a per capita basis, the ASA felt they would be providing most of the finances of the organization without an equal voice in its government. There was also reluctance on the part of some American anesthesiologists to join an organization that had communists among its members. Time, dialogue, and the performance of the WFSA eliminated those fears.[47]

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 that believed no physicians 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. Enforcement of this edict was done by the component societies of the ASA, for an anesthesiologist could not be a member if he or she was not a component society member. Furthermore, to be eligible to take the ABA examination, an anesthesiologist had to be an ASA member.[48] In response to this, the Association of University Anesthesiologists (AUA) was formed. Most 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 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.[49] It was a rapid expansion and one that continued to delineate the scientific underpinnings of the specialty. The AUA was also the first subspecialty society formed in anesthesiology and worked to promote scientific research and teaching in anesthesiology.

In the 1960s, the US federal government sought to support medical research and created the National Institutes of Health (NIH). Emmanuel Papper (**Fig. 1-10**) was invited to Washington DC, to help organize the new agency. 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.[41]

The 1970s was a decade of crisis for anesthesiology. To ensure billing commensurate with services, the ASA had endorsed a relative value guide that helped place a unit value on work done by the physician. Other specialties, including orthopedics and radiology, had adopted similar guides, but the Federal Trade Commission (FTC) thought this was a monopolistic practice. All of the specialties but anesthesiology agreed to cease and desist; the ASA 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

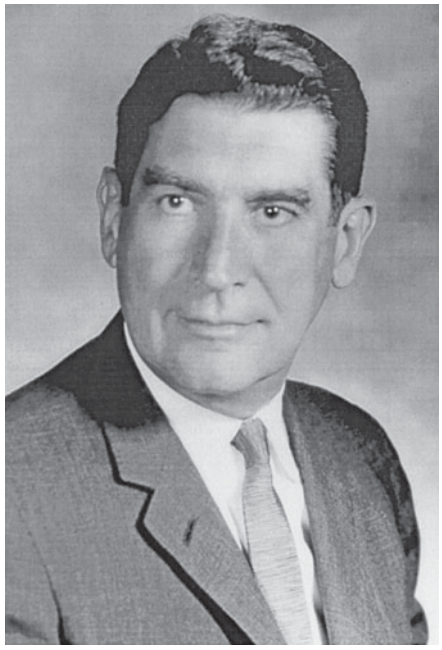

**FIGURE 1-10.** Emmanuel Papper. [Photograph courtesy of the Wood Library-Museum of Anesthesiology.]

states the relative value guides are the preferred billing methodology. The 1970s also saw another federal government suit against the ASA for the fee-for-service rule. While there was little chance of a successful suit, the federal government, cautious after its defeat, agreed to a cease-and-desist order.[50]

The 1970s also oversaw the beginnings of the subspecialty movement in anesthesiology. Just before the beginning of the decade, the Society for Obstetric Anesthesia and Perinatology was formed in 1968. The group remains diverse with anesthesiologists, obstetricians, and perinatologists all presenting work of interest to the group.[51] Likewise in the early 1970s, Maurice Albin and others interested in neuroanesthesia created the Society of Neurosurgical Anesthesia. John Mitchenfelder was the first president in 1973.[52] Two years later, the American Society of Regional Anesthesia (ASRA) was reformed, although without knowledge of the group formed by Gaston Labat in the 1920s. Dedicated to the promotion of regional anesthesia, which also meant teaching and research, the society has grown and prospered. Publishing the first subspecialty journal, *Regional Anesthesia*, the society provided a place for a peer-reviewed publication in regional anesthesia. Coupled with the annual meeting, where information and demonstrations about the topic were presented, the society also provided a forum for anesthesiologists interested in pain medicine to interact. Eventually the society would change its name to the American Society of Regional Anesthesia and Pain Medicine and the name of journal to *Regional Anesthesia and Pain Medicine* emphasizing the importance of this emerging field in anesthesiology.[53] Mid-decade, the Society of Cardiovascular Anesthesiologists came into being. This group disseminated information about cardiac bypass and the emerging fields 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) is devoted to the promotion of research within the specialty. The group has a special interest in those just beginning their careers, and it 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 when FAER was being established, the Anesthesia Patient Safety Foundation (APSF) was created. Its mission is simple: No patient should ever be harmed by an anesthetic. APSF has partnered 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. APSF and its work is the model for the patient safety movement across the country, and it is used by the AMA as a model for its patient safety foundation.[54]

The subspecialty movement in anesthesiology 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 the care of children undergoing anesthesia, not simply anesthesiologists in full-time pediatric practice. Another society formed in the mid-1980s was the Society for Ambulatory Anesthesia.[55] In response to the growing trend of day surgery and having patients return home on the day of operation rather than spending a night in the hospital, the society strove and continues to strive for the highest standards in anesthesia care in the ambulatory setting.[56] Likewise the American Society of Critical Care Anesthesiologists was formed to establish a forum where anesthesiologists interested in critical care could meet to exchange ideas and information.[57]

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 medicine and pain medicine. This trend continues to the present with added qualifications available in palliative care and pediatrics. One of the greatest challenges before anesthesiology currently remains the proper role for these credentials in the clinical setting and which subspecialties are appropriate to endorse for them.

## CONCLUSIONS

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

> 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.[58]

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 replete with the highest examples of professionalism, and the best is yet to come!

## KEY REFERENCES


- Bacon DR. The New York Society of Anesthetists: building the foundation. In: Bacon DR, Lema MJ, McGoldrick KE, eds. *The American Society of Anesthesiologists: A Century of Challenges and Progress*. Park Ridge, IL: Wood Library-Museum of Anesthesiology Press; 2005:9-18.
- Bacon DR. The World Federation of Societies of Anesthesiologists (WFSA): McMechan's final legacy? *Anesth Analg.* 1997;84:1130-1135.
- Bacon DR, Lema MJ. To define a specialty: a brief history of the American Board of Anesthesiology's first written examination. *J Clin Anesth.* 1992;4:489-497.
- Fenster J. *Ether Day*. New York, NY: HarperCollins; 2001.
- Goerig M, Agarwal K, Schulte am Esch J. The versatile August Bier (1861-1949), father of spinal anesthesia. *J Clin Anesth.* 2000;12:561-569.
- Griffith HR, Johnson GE. The use of curare in general anesthesia. *Anesthesiology.* 1942;3:418-420.
- Johansen PV, Paneth N, Rachman S, Rip M. *Cholera, Chloroform, and the Science of Medicine: A Life of John Snow*. New York, NY: Oxford University Press; 2003:113.
- Smith HM, Bacon DR. The history of anesthesia. In: Barash P, Cullen B, Stoelting R, eds. *Clinical Anesthesia*. 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005:3-26.
- Waisel DB. The role of World War II and the European theater of operations in the development of anesthesiology as a physician specialty in the USA. *Anesthesiology*. 2001;94(5):907-914.
- Wells CJ. Francis Hoeffer McMechan. *Curr Res Anesth Analg.* 1948;26(Suppl):1-19


## REFERENCES

Complete references available on DVD and online version at www.LongneckerAnesthesiology.com

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 anesthesiologists.
2. The anesthesiologist's primary responsibility is to ensure patients' comfort and safety when they are exposed to the trespass of surgery.
3. The intraoperative conduct of anesthesia has effects on patient safety and comfort in the postoperative period.
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. It is arithmetically impossible to provide a fully trained individual anesthesiologist for every anesthetic procedure.
6. Meeting the labor, safety, and cost demands of the future will require that we overcome the political infighting between organized anesthesiology and nurse anesthesia.
7. Many believe it is important for the future of the specialty that anesthesiologists increase their commitment to critical care medicine.
8. Recent advances in knowledge and technology create an enormous opportunity for anesthesiologists to address the scientific questions at the core of the specialty as well as a variety of important clinical problems.
9. Apart from traditional areas of involvement, such as operating room anesthesia, critical care, pain medicine, teaching, research, and resuscitation, there will be future opportunities for anesthesiologists in pharmacogenomics, health care systems management, and new technologies.

Anesthesiology arose as a medical specialty because the dangers associated with anesthetic drugs and techniques demanded that they be administered 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 most of the trainees who were initially attracted by critical care subsequently practiced operating room anesthesia only. In contrast, anesthesiologists in Europe and Canada were consolidating their positions 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. In the last 10 years, US anesthesiology programs have enjoyed a revival, and many talented medical graduates have chosen to enter the specialty. Another encouraging recent trend has been the marked increase in the proportion of US graduating residents who are choosing to pursue fellowships to bolster their specialist knowledge and refine their clinical skills. All anesthesiology subspecialties (eg, pain medicine, critical care, pediatrics, clinical scientist) are benefiting from this growing cadre of subspecialists. Anesthesiologists in the other parts of the world have also experienced fluctuating fortunes. Currently there is a shortage of doctors, in general, and anesthesiologists, in particular, in many countries. The future of anesthesiology depends on several factors, including changes in surgery and interventional medical 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; health care financing will also influence trends in anesthesia practice. This chapter briefly reviews 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 the 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. Over the past decades it has become increasingly clear that the intraoperative conduct of anesthesia has profound effects on patient safety and comfort in the postoperative period. For example, modest intraoperative hypothermia can either decrease the incidence of wound infection[1] or provide neuroprotection[2] depending on the clinical situation. 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. Recent research shows that an estimated 1.85% of adult patients die within 30 days of undergoing operations across the entire surgical spectrum, with some operations having much higher mortality (eg, vascular surgery: 5.97%) and others having lower mortality (eg, breast surgery: 0.07%).[3] It is likely that, with appropriate interventions, many of these deaths could be prevented. This 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.[4]

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. One widely cited study from the United Kingdom, the Confidential Enquiry Into Perioperative Deaths (CEPOD), reports that patients undergoing general anesthesia have a 1 in 185 000 chance of dying as a consequence of anesthetic misadventure.[5-7] This finding was highlighted in the Institute of Medicine report on medical errors,[8] and anesthesiology was cited as the specialty that had best addressed safety issues (see Chapter 3 for a more comprehensive review of quality and safety in anesthesia practice). Unfortunately, this widely publicized perception that anesthesia is "safe" has encouraged nonphysician anesthesia providers to advocate for independent practice and has suggested to insurers that anesthesia care by an anesthesiologist is needlessly expensive. However, studies from other countries have reported much higher rates of death attributable to anesthesia than those reported in the CEPOD study.[9] In a large French study, the perioperative mortality directly attributable to anesthesia was found to be 1 in 13,000.[10] In studies reported from Australia,[11] Denmark,[12] Finland,[13] and the Netherlands,[14] perioperative death attributable to anesthesia ranged from 1 in 2500[12] to 1 in 67,000.[13] The mortality attributable to anesthesia is probably much greater in underdeveloped countries. For example, a 1992 study from a Zimbabwean teaching hospital reported an alarming incidence of death or coma attributable to anesthesia of 1 in 388.[15] Whereas the bulk of evidence suggests that anesthesia is not nearly as safe as publicized,[16] it is undoubtedly true that advances in anesthetic practice in developed countries have rendered the care of healthy patients undergoing low- or intermediate-risk surgery much safer than in the past (see Chapter 25 for a more detailed review of anesthesia risk).

The 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 general anesthesia for screening colonoscopy, and by the introduction of freestanding ambulatory surgery centers and office-based surgical suites where anesthesia is administered. The demands for safe anesthesia care provided in numerous remote locations present significant challenges to the workforce, financing, and practice of anesthesiology.

Current practice models vary widely both in 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 ancillary providers (eg, nurse anesthetists, residents, or anesthesia assistants) in more than one operating room, a practice model that is also common in the Netherlands. The provision of safe anesthetic care across geographically dispersed practice sites and encompassing wide ranges of severity of patient illness, in an economically responsible manner, is a major challenge that anesthesiologists need to address proactively.

The expectations for operating room anesthesia can be simply stated: W*e will need to provide an ever-increasing quality of perioperative care for 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 provider, and how the responsibility for care will be organized, managed, and rewarded.

Currently, at least 50% of anesthesia care in the United States involves nurse anesthetists; in several states, physician supervision is not mandatory. Worldwide, anesthesia practice often includes some form of nonphysician provider or physician provider who is not a fully trained anesthesiologist. For example, staff-grade noncertified anesthetists provide a significant proportion of anesthesia care in the United Kingdom. There is one report asserting that nonanesthesiologists can safely provide anesthesia for selected procedures (eg, colonoscopy) and patients.[17] It is also clear that patients with minimal physiologic reserve, those undergoing major interventions, and those with complex medical problems require the direct involvement of a skilled anesthesiologist to enhance patient safety.[18,19] Unfortunately, practitioner skill and experience are often not matched to these factors but determined by the availability of providers or a fixed model of care delivery rather than one tailored to the specific clinical situation. This is a fruitful area for further work by anesthesiologists to ensure proper matching of resources to clinical needs.

It is arithmetically impossible to provide a fully trained individual anesthesiologist for every anesthetic procedure. 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 do not have the capacity to train sufficient doctors to feed exponentially increasing anesthesia programs. 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 providers. 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 providers, allowing them to perform at the highest levels their training allows 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 of telemedicine could make this model of care feasible even in communities where an anesthesiologist is not physically present.[20] Meeting the labor, safety, and cost demands of the future will require that we overcome the political infighting between organized anesthesiology and nurse anesthesia. Further, the training of anesthesiologists will increasingly need to encompass the development of skills in supervising other anesthesia providers. It is in the interests of public safety and health care delivery that unity be forged among anesthesia providers under the leadership of specialist anesthesiologists, whose medical training and education is required for complex medical decision making, supplemented by the skills and abilities of nonphysician providers who enhance this team approach.

## OUTSIDE THE OPERATING ROOM

### PREOPERATIVE CARE

Perioperative morbidity is frequently attributable to poor preoperative patient assessment and optimization. These roles have always been integral to the anesthesiologist's practice. However, as patients increasingly

present to the hospital on the day of surgery, 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 4 for a more detailed discussion of the benefits and operation of preoperative clinics). In some practice settings, preoperative assessment of complicated patients has been largely relegated to non–anesthesiology-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 optimal. From the standpoint of continuity of care and so that anesthesiologists can implement best practices that contribute to the continuum of care and long-term outcomes, 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 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, both because of 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.[21] In many countries, 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 it is important for the future of the specialty that anesthesiologists increase their commitment 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 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. 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 has decreased while that for most other specialties has steadily increased (some dramatically). The Anesthesia Patient Safety Foundation 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 claims files for anesthesia-related patient injuries.[22] More than 5000 claims have been studied. Subsequently, the Australian Patient Safety Foundation was established in 1987 and the Australian Incident Monitoring Study was initiated.[23] More than 4000 critical incidents have been reported to date. Analysis of these incidents has reinforced the value of technological advances, such as capnography and oximetry, in improving patient safety. The results also confirm the value of structured algorithms in anesthesia care, by documenting favorable outcomes in a range of life-threatening crises during anesthesia. CEPOD was started in the United Kingdom in 1989. Changes in consultant practice, increase in medical audits, improvement in physiologic monitoring, appropriate matching of specialist experience to patient's medical conditions, and increased awareness of the need for critical care services are believed to have been influenced by this inquiry.[24]

Critical events occur within the context of complex system failures, and anesthesiologists have been developing safeguards to decrease the likelihood that human error may result in patient harm. Examples include written "checklists," audible alarm settings, and automated anesthesia machine checks. 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.[25] 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, obstetric 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 they constituted pioneering efforts in the initial application of scientific principles to individual patient care. Until recently many of the scientific questions at the core of anesthesiology have been relatively inaccessible to investigation; this stems from the absence of tools to study the mechanisms of the complex behaviors (eg, consciousness, memory, pain) that anesthesiologists manipulate. Recent advances in cellular physiology (ie, patch clamp recording), molecular biology, genetics, functional imaging, and behavioral sciences have enabled serious investigation of these complex behaviors. It is thus now possible that the fundamental mysteries of anesthesia (including the molecular mechanism of the hypnotic, amnestic, and analgesic effects of anesthetics agents) will be solved. These same new scientific tools also make it feasible to define the mechanisms of hyperalgesia and chronic pain and to design effective treatments. Finally, advances in the understanding and manipulation of inflammation and the immune response provide a new opportunity to delineate how organ system injury occurs in the perioperative period and to identify strategies for protection of the brain, heart, kidneys, and other organs. Collectively, recent advances in knowledge and technology create an enormous opportunity for anesthesiology to address the scientific questions at the core of the specialty, as well as a variety of important