6th edition

Morgan & Mikhail's CLINICAL ANESTHESIOLOGY

John F. Butterworth • David C. Mackey • John D. Wasnick

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Morgan & Mikhail's Clinical Anesthesiology

SIXTH EDITION

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Foreword

When a new residency training program in anesthesia was beginning in Rwanda in 2006, we were looking for a suitable textbook to recommend to the trainees. We chose Clinical Anesthesiology by Morgan and Mikhail. I am happy to state that today, 12 years later, the residents are still making the same choice. Over one third of all copies of the last edition were sold outside of North America thus underlining the popularity of this textbook around the world.

A major change in editors and authors occurred with the 5th edition and it is clear that they stayed true to the ideals of the original editors. Now in 2018, the 6th edition is presented to us. The text continues to be simple, concise, and easily readable. The use of Key Concepts at the beginning of each chapter is very useful and focuses the reader's attention on the important points. The authors have worked hard not to increase the size of the book but to update the material. Expanded chapters on critical care, on enhanced recovery after anesthesia, and on the use of ultrasound will be very useful to readers. This textbook continues to provide a comprehensive introduction to the art and science of anesthesia.

Congratulations to the authors and editors on their fine work.

Angela Enright MB, FRCPC
Past President, World Federation of Societies of Anaesthesiologists (WFSA)

Preface

My, how time flies! Can half a decade already have passed since we last edited this textbook? Yet, the time has passed and our field has undergone many changes. We are grateful to the readers of the fifth edition of our textbook. The widespread use of this work have ensured that the time and effort required to produce a sixth edition are justified.

As was true for the fifth edition, the sixth edition represents a significant revision. A few examples are worth noting:

- Those familiar with the sequence and grouping of content in the fifth edition will notice that chapters have been reordered and content broken out or consolidated to improve the flow of information and eliminate redundancy.
- The alert reader will note that the section on **critical care medicine** has been expanded, reflecting the increasing number of very sick patients for whom we care.
- Enhanced recovery after surgery has progressed from an important concept to a commonly used acronym (**ERAS**), a specialty society, and (soon) standard of care.
- **Ultrasound** has never been more important in anesthesia practice, and its use in various procedures is emphasized throughout the textbook.

Some things remain unchanged:

- We have not burdened our readers with large numbers of unnecessary **references**. We hope that long lists of references at the end of textbook chapters will soon go the way of the library card catalog and long-distance telephone charges. We assume that our readers are as fond of (and likely as facile with) Google Scholar and PubMed as are we, and can generate their own lists of references whenever they like. We continue to provide URLs for societies, guidelines, and practice advisories.
- We continue to emphasize **Key Concepts** at the beginning of each chapter that link to the chapter discussion, and **case discussions** at the end.

- We have tried to provide **illustrations and images** whenever they improve the flow and understanding of the text.

Once again, the goal expressed in the first edition remains unchanged: “to provide a concise, consistent presentation of the basic principles essential to the modern practice of anesthesia.” And, once again, despite our best intentions, we fear that errors will be found in our text. We are grateful to the many readers who helped improve the last edition. Please email us at mm6edition@gmail.com when you find errors. This enables us to make corrections in reprints and future editions.

John F. Butterworth, IV, MD
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CHAPTER
1

The Practice of Anesthesiology

KEY CONCEPTS

1. Oliver Wendell Holmes in 1846 was the first to propose use of the term *anesthesia* to denote the state that incorporates amnesia, analgesia, and narcosis to make painless surgery possible.
2. Ether was used for frivolous purposes ("ether frolics") and was not used as an anesthetic agent in humans until 1842, when Crawford W. Long and William E. Clark independently used it on patients. On October 16, 1846, William T.G. Morton conducted the first publicized demonstration of general anesthesia for surgical operation using ether.
3. The original application of modern local anesthesia is credited to Carl Koller, at the time a house officer in ophthalmology, who demonstrated topical anesthesia of the eye with cocaine in 1884.
4. Curare greatly facilitated tracheal intubation and muscle relaxation during surgery. For the first time, operations could be performed on patients without the requirement that relatively deep levels of inhaled general anesthetic be used to produce muscle relaxation.
5. John Snow, often considered the father of the anesthesia specialty, was the first to scientifically investigate ether and the physiology of general anesthesia.
6. The "captain of the ship" doctrine, which held the surgeon responsible for every aspect of the patient's perioperative care (including anesthesia), is no longer a valid notion when an anesthesiologist is present.

The Greek philosopher Dioscorides first used the term *anesthesia* in the first century AD to describe the narcotic-like effects of the plant *mandragora*. The term subsequently was defined in Bailey's *An Universal Etymological English*

Dictionary (1721) as “a defect of sensation” and again in the *Encyclopedia Britannica* (1771) as “privation of the senses.” Oliver Wendell Holmes in 1846 was the first to propose use of the term to denote the state that incorporates amnesia, analgesia, and narcosis to make painless surgery possible. In the United States, use of the term *anesthesiology* to denote the practice or study of anesthesia was first proposed in the second decade of the twentieth century to emphasize the growing scientific basis of the specialty.

Although anesthesia now rests on scientific foundations comparable to those of other specialties, the practice of anesthesia remains very much a mixture of science and art. Moreover, the practice has expanded well beyond rendering patients insensible to pain during surgery or obstetric delivery (**Table 1–1**). Anesthesiologists require a working familiarity with a long list of other specialties, including surgery and its subspecialties, internal medicine, pediatrics, palliative care, and obstetrics, as well as imaging techniques (particularly ultrasound), clinical pharmacology, applied physiology, safety science, process improvement, and biomedical technology. Advances in scientific underpinnings of anesthesia make it an intellectually stimulating and rapidly evolving specialty. Many physicians entering residency positions in anesthesiology will already have multiple years of graduate medical education and perhaps certification in other medical specialties.

TABLE 1–1 Aspects of the practice of medicine that are included within the scope of anesthesiology.[1]

Assessment of, consultation for, and preparation of patients for anesthesia.
Relief and prevention of pain during and following surgical, obstetric, therapeutic, and diagnostic procedures.
Monitoring and maintenance of normal physiology during the perioperative or periprocedural period.
Management of critically ill patients.
Diagnosis and treatment of acute, chronic, and cancer-related pain.
Management of hospice and palliative care.
Clinical management and teaching of cardiac, pulmonary, and neurological resuscitation.
Evaluation of respiratory function and application of respiratory therapy.
Conduct of clinical, translational, and basic science research.
Supervision, teaching, and evaluation of performance of both medical and allied health personnel involved in perioperative or periprocedural care, hospice and palliative care, critical care, and pain management.
Administrative involvement in health care facilities and organizations, and medical schools, as appropriate to the American Board of Anesthesiology's mission.

[1]Data from the American Board of Anesthesiology Primary Certification Policy Book (Booklet of Information), 2017.

This chapter reviews the history of anesthesia, emphasizing its British and American roots, and considers the current scope of the specialty.

The History of Anesthesia

The specialty of anesthesia began in the mid-nineteenth century and became firmly established in the following century. Ancient civilizations had used opium poppy, coca leaves, mandrake root, alcohol, and even phlebotomy (to the point of unconsciousness) to allow surgeons to operate. Ancient Egyptians used the combination of opium poppy (containing morphine) and hyoscyamus (containing scopolamine) for this purpose. A similar combination, morphine and

scopolamine, was widely used for premedication until recent times. What passed for regional anesthesia in ancient times consisted of compression of nerve trunks (nerve ischemia) or the application of cold (cryoanalgesia). The Incas may have practiced local anesthesia as their surgeons chewed coca leaves and applied them to operative wounds, particularly prior to trephining for headache.

The evolution of modern surgery was hampered not only by a poor understanding of disease processes, anatomy, and surgical asepsis but also by the lack of reliable and safe anesthetic techniques. These techniques evolved first with inhalation anesthesia, followed by local and regional anesthesia, intravenous anesthesia, and neuromuscular blockers. The development of surgical anesthesia is considered one of the most important discoveries in human history, and it was introduced to practice without a supporting randomized clinical trial.

INHALATION ANESTHESIA

Because the hypodermic needle was not invented until 1855, the first general anesthetics were destined to be inhalation agents. Diethyl ether (known at the time as “sulfuric ether” because it was produced by a simple chemical reaction between ethyl alcohol and sulfuric acid) was originally prepared in 1540 by Valerius Cordus. Ether was used for frivolous purposes (“ether frolics”), but not as an anesthetic agent in humans until 1842, when Crawford W. Long and William E. Clark independently used it on patients for surgery and dental extraction, respectively. However, neither Long nor Clark publicized his discovery. Four years later, in Boston, on October 16, 1846, William T.G. Morton conducted the first publicized demonstration of general anesthesia for surgical operation using ether. The dramatic success of that exhibition led the operating surgeon to exclaim to a skeptical audience: “Gentlemen, this is no humbug!”

Chloroform was independently prepared by Moldenhawer, von Liebig, Guthrie, and Soubeiran around 1831. Although first used by Holmes Coote in 1847, chloroform was introduced into clinical practice by the Scot Sir James Simpson, who administered it to his patients to relieve the pain of labor. Ironically, Simpson had almost abandoned his medical practice after witnessing the terrible despair and agony of patients undergoing operations without anesthesia.

Joseph Priestley produced nitrous oxide in 1772, and Humphry Davy first noted its analgesic properties in 1800. Gardner Colton and Horace Wells are

credited with having first used nitrous oxide as an anesthetic for dental extractions in humans in 1844. Nitrous oxide's lack of potency (an 80% nitrous oxide concentration results in analgesia but not surgical anesthesia) led to clinical demonstrations that were less convincing than those with ether.

Nitrous oxide was the least popular of the three early inhalation anesthetics because of its low potency and its tendency to cause asphyxia when used alone (see Chapter 8). Interest in nitrous oxide was revived in 1868 when Edmund Andrews administered it in 20% oxygen; its use was, however, overshadowed by the popularity of ether and chloroform. Ironically, nitrous oxide is the only one of these three agents still in use today. Chloroform superseded ether in popularity in many areas (particularly in the United Kingdom), but reports of chloroform-related cardiac arrhythmias, respiratory depression, and hepatotoxicity eventually caused practitioners to abandon it in favor of ether, particularly in North America.

Even after the introduction of other inhalation anesthetics (ethyl chloride, ethylene, divinyl ether, cyclopropane, trichloroethylene, and fluroxene), ether remained the standard inhaled anesthetic until the early 1960s. The only inhalation agent that rivaled ether's safety and popularity was cyclopropane (introduced in 1934). However, both are highly combustible and both have since been replaced by a succession of nonflammable potent fluorinated hydrocarbons: halothane (developed in 1951; released in 1956), methoxyflurane (developed in 1958; released in 1960), enflurane (developed in 1963; released in 1973), and isoflurane (developed in 1965; released in 1981).

Currently, sevoflurane is by far the most popular inhaled agent in developed countries. It is far less pungent than isoflurane and has low blood solubility. Ill-founded concerns about the potential toxicity of its degradation products delayed its release in the United States until 1994 (see Chapter 8). These concerns have proved to be theoretical. Sevoflurane is very suitable for inhaled inductions and has largely replaced halothane in pediatric practice. Desflurane (released in 1992) has many of the desirable properties of isoflurane as well as more rapid uptake and elimination (nearly as fast as nitrous oxide). Sevoflurane, desflurane, and isoflurane are the most commonly used inhaled agents in developed countries worldwide.

LOCAL & REGIONAL ANESTHESIA

The medicinal qualities of coca had been recognized by the Incas for centuries before its actions were first observed by Europeans. Cocaine was isolated from

coca leaves in 1855 by Gaedicke and was purified in 1860 by Albert Niemann. Sigmund Freud performed seminal work with cocaine. Nevertheless, the original application of cocaine for anesthesia is credited to Carl Koller, at the time a house officer in ophthalmology, who demonstrated topical anesthesia of the eye in 1884. Later in 1884 William Halsted used cocaine for intradermal infiltration and nerve blocks (including blocks of the facial nerve, brachial plexus, pudendal nerve, and posterior tibial nerve). August Bier is credited with administering the first spinal anesthetic in 1898. He was also the first to describe intravenous regional anesthesia (Bier block) in 1908. Procaine was synthesized in 1904 by Alfred Einhorn and within a year was used clinically as a local anesthetic by Heinrich Braun. Braun was also the first to add epinephrine to prolong the duration of local anesthetics. Ferdinand Cathelin and Jean Sicard introduced caudal epidural anesthesia in 1901. Lumbar epidural anesthesia was described first in 1921 by Fidel Pages and again (independently) in 1931 by Achille Dogliotti. Additional local anesthetics subsequently introduced include dibucaine (1930), tetracaine (1932), lidocaine (1947), chloroprocaine (1955), mepivacaine (1957), prilocaine (1960), bupivacaine (1963), and etidocaine (1972). The most recent additions, ropivacaine (1996) and levobupivacaine (1999), have durations of action similar to bupivacaine but less cardiac toxicity (see Chapter 16). Another, chemically dissimilar local anesthetic, articaine, has been widely applied for dental anesthesia.

INTRAVENOUS ANESTHESIA

Induction Agents

Intravenous anesthesia required the invention of the hypodermic syringe and needle by Alexander Wood in 1855. Early attempts at intravenous anesthesia included the use of chloral hydrate (by Oré in 1872), chloroform and ether (Burkhardt in 1909), and the combination of morphine and scopolamine (Bredenfeld in 1916). Barbiturates were first synthesized in 1903 by Fischer and von Mering. The first barbiturate used for induction of anesthesia was diethylbarbituric acid (barbital), but it was not until the introduction of hexobarbital in 1927 that barbiturate induction became popular. Thiopental, synthesized in 1932 by Volwiler and Tabern, was first used clinically by John Lundy and Ralph Waters in 1934 and for many years it remained the most common agent for intravenous induction of anesthesia. Methohexital was first used clinically in 1957 by V.K. Stoelting. Methohexital continues to be very popular for brief general anesthetics for electroconvulsive therapy. After