SABISTON TEXTBOOK of SURGERY

The BIOLOGICAL BASIS of MODERN SURGICAL PRACTICE

TOWNSEND
BEAUCHAMP • EVERS • MATTOX

20TH EDITION

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ISBN: 978-0-323-29987-9
International Edition ISBN: 978-0-323-40162-3

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Please change to the following:

Library of Congress Cataloging-in-Publication Data

Sabiston textbook of surgery : the biological basis of modern surgical practic / [edited by] Courtney M. Townsend, Jr, R. Daniel Beauchamp, B. Mark Evers, Kenneth L. Mattox.—20th edition.
p. ; cm.
Textbook of surgery
Preceded by Sabiston textbook of surgery / [edited by] Courtney M. Townsend Jr. … [et al.]. 19th ed. 2012.
Includes bibliographical references and index.
ISBN 978-0-323-29987-9 (hardcover : alk. paper)—ISBN 978-0-323-40162-3 (international edition : alk. paper)
I. Townsend, Courtney M., Jr., editor. II. Beauchamp, R. Daniel, editor. III. Evers, B. Mark, 1957-, editor. IV. Mattox, Kenneth L., 1938-, editor. V. Title: Textbook of surgery.
[DNLM: 1. Surgical Procedures, Operative. 2. General Surgery. 3. Perioperative Care. WO 500]
RD31
617—dc23

2015035365

Executive Content Strategist: Michael Houston
Content Development Specialist: Joanie Milnes
Publishing Services Manager: Patricia Tannian
Senior Project Manager: Cindy Thoms
Book Designer: Renee Duenow

Printed in Canada

Last digit is the print number: 9 8 7 6 5 4 3 2 1

To our patients, who grant us the privilege of practicing our craft;
to our students, residents, and colleagues, from whom we learn;
and to our wives—Mary, Shannon, Karen, and June—without
whose support this would not have been possible.

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A SCORE OF SCORES

This 20th or "Score" edition of *Sabiston's Textbook of Surgery* represents both a culmination and the continuation of the record of the 19 preceding editions, each of which scored their goal of serving as surgery's English language evidence-based reference work. The tradition of providing expansive update information, including detailed exposition of surgical pathophysiology to assist the surgeon in his/her adaptation of generic data for an innovative solution of an atypical clinical problem, has been maintained in this edition. The first two sections of this edition characterize, in detail, the systemic and organ specific responses to injury, describe perioperative management (including anesthesia), and cover the diagnosis and treatment of surgical infections and other surgical complications. The third section is devoted to trauma and critical care in recognition of the fact that surgical intervention is in itself a controlled form of trauma and that critical care expertise is essential to optimize surgical outcomes. Those initial three sections also contain chapters on ethics and professionalism, critical analysis of outcomes, patient safety issues, surgical aspects of mass casualty incidents, and a preview of the potential benefits of emerging technologies such as informatics, electronics, and robotics. Collectively the information in those sections prepares the reader to evaluate and use the current best-evidence-based recommendations for the management of surgical disease of organ systems and tissues as presented in the subsequent nine sections. The last section consists of seven chapters in which essential subspecialty-specific principles are enunciated and related to general surgery practice to complete the picture of surgery as a medical discipline.

This new edition, which is designed to meet the information format preferences of medical students, residents, fellows, and practicing surgeons of all ages, is available in both print and electronic format including that for e-readers such as Kindle. Additionally, this edition has a website called Expert Consult (www.expertconsult.com), which enables the reader to obtain enhanced content such as interactive images that can be used to generate slideshow presentations and annotated test-yourself material, and, with variable magnification, optimize visualization of specific image details.

Dr. Townsend, the editorial descendant of Christopher, Davis, and Sabiston, and his associate editors have generated an effective mix of authoritative senior authors, with voices heard in previous editions and thoroughly updated in this volume, and carefully chosen rising stars to promote clinically useful understanding of the principles guiding surgical intervention. In the aggregate this textbook promotes the concept of "precision surgery," which has developed during the eight decades since 1936 when Frederick Christopher published the first edition of his *Textbook of Surgery* from which this volume has descended. As such, this new edition will enhance the reader's ability to optimize the diagnosis of surgical disease and the treatment of surgical patients. In short, this new "Score" edition has scored again by extending the reign of *Sabiston's Textbook of Surgery* as the "…definitive treatise on surgical practice" as cited by a perceptive reviewer of the 18th edition in 2008.

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Dries DJ. Book review. *Sabiston's Textbook of Surgery: The biological basis of modern surgical practice,* 18th edition. Shock 2008; 29: 650.

PREFACE

Surgery continues to evolve as new technology, techniques, and knowledge are incorporated into the care of surgical patients. The 20th edition of *Sabiston Textbook of Surgery* reflects these exciting changes and new knowledge. We have incorporated more than 50 new authors to ensure that the most current information is presented. This new edition has revised and enhanced the current chapters to reflect these changes.

The primary goal of this new edition is to remain the most thorough, useful, readable, and understandable textbook presenting the principles and techniques of surgery. It is designed to be equally useful to students, trainees, and experts in the field. We are committed to maintaining this tradition of excellence begun in 1936. Surgery, after all, remains a discipline in which the knowledge and skill of a surgeon combine for the welfare of our patients.

Courtney M. Townsend, Jr., MD

ACKNOWLEDGMENTS

We would like to recognize the invaluable contributions of Karen Martin, Steve Schuenke, and Eileen Figueroa, and administrator Barbara Petit. Their dedicated professionalism, tenacious efforts, and cheerful cooperation are without parallel. They accomplished whatever was necessary, often on short or instantaneous deadlines, and were vital for the successful completion of the endeavor.

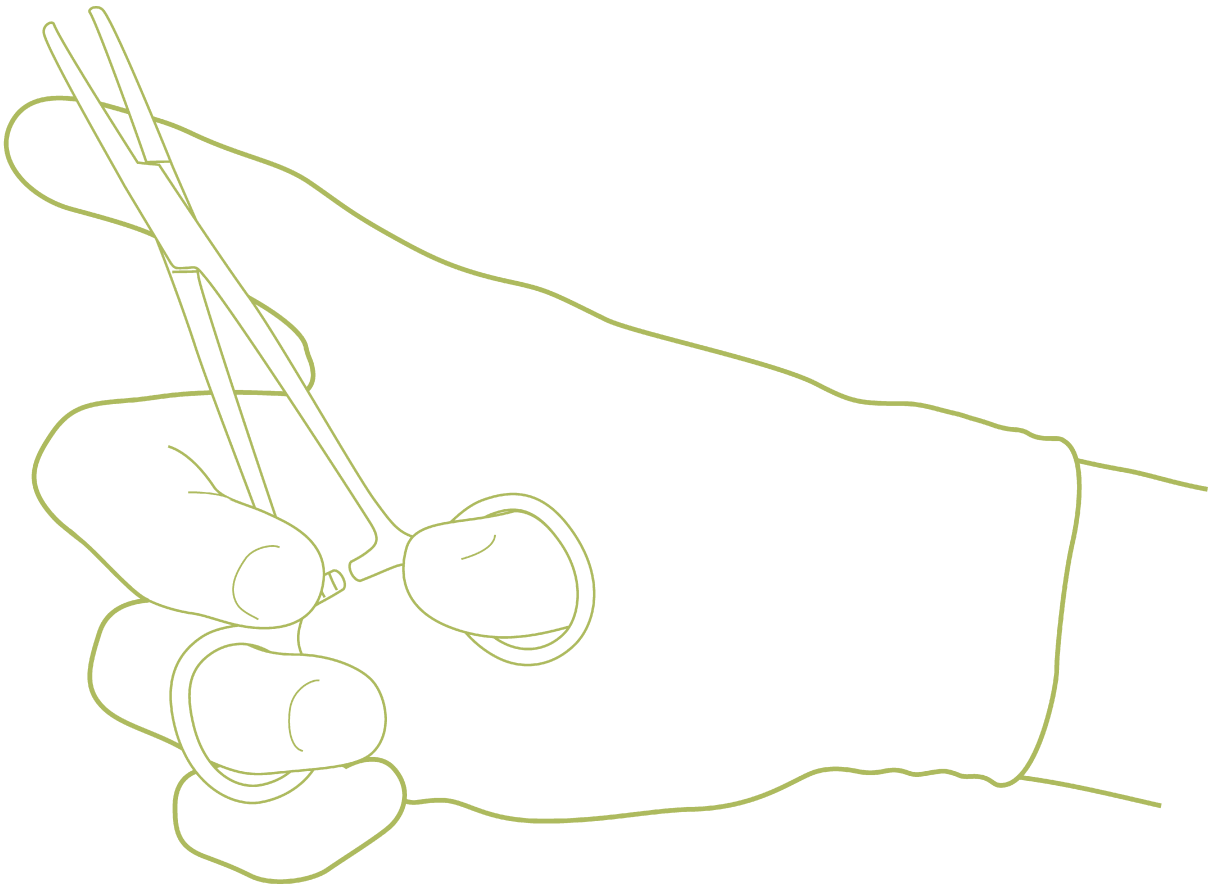
Our authors, respected authorities in their fields and busy physicians and surgeons, all did an outstanding job in sharing their wealth of knowledge.

We would also like to acknowledge the professionalism of our colleagues at Elsevier: Michael Houston, Executive Content Strategist; Joanie Milnes, Content Development Specialist; Patricia Tannian, Publication Services Manager; and Cindy Thoms, Senior Project Manager.

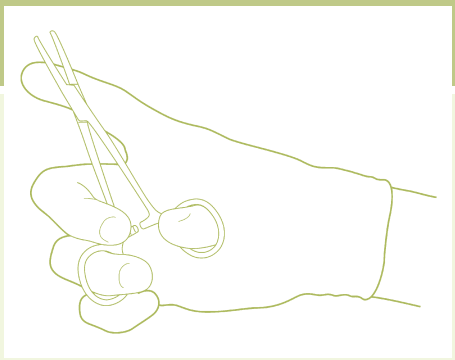
VIDEO CONTENTS

SECTION I

Surgical Basic Principles



1 CHAPTER



The Rise of Modern Surgery: An Overview

Ira Rutkow

"If there were no past, science would be a myth; the human mind a desert. Evil would preponderate over good, and darkness would overspread the face of the moral and scientific world."

Samuel D. Gross (Louisville Review 1:26–27, 1856)

CHAPTER OUTLINE

THE BEGINNINGS

From earliest recorded history through late in the 19th century, the manner of surgery changed little. During those thousands of years, surgical operations were always frightening, often fatal, and frequently infected. In this prescientific, preanesthetic, and preantiseptic time, procedures were performed only for the most dire of necessities and were unlike anything seen today; fully conscious patients were held or tied down to prevent their fleeing the surgeon's unsparing knife. When the surgeon, or at least those persons who used the sobriquet "surgeon," performed an operation, it was inevitably for an ailment that could be visualized (i.e., on the skin and just below the surface, on the extremities, or in the mouth).

Through the 14th century, most surgical therapy was delivered by minimally educated barber-surgeons and other itinerant adherents of the surgical cause. These faithful but obscure followers of the craft of surgery, although ostracized by aristocratic, university-educated physicians who eschewed the notion of working with one's hands, ensured the ultimate survival of what was then a vocation passed on from father to son. The roving "surgeons" mainly lanced abscesses; fixed simple fractures; dressed wounds; extracted teeth; and, on rare occasions, amputated a digit, limb, or breast. Around the 15th century, the highborn physicians began to show an interest in the art of surgery. As surgical techniques evolved, knife bearers, whether privileged physicians or wandering vagabonds, ligated arteries for readily accessible aneurysms, excised large visible tumors, performed trephinations, devised ingenious methods to reduce incarcerated and strangulated hernias, and created rudimentary colostomies and ileostomies by simply incising the skin over an expanding intra-abdominal mass that represented the end stage of an intestinal blockage. The more entrepreneurial scalpel wielders widened the scope of their activities by focusing on the care of anal fistulas, bladder stones, and cataracts. Notwithstanding the growing boldness and ingenuity of "surgeons," surgical operations on the cavities of the body (i.e., abdomen, cranium, joints, and thorax) were generally unknown and, if attempted, fraught with danger.

Despite the terrifying nature of surgical intervention, operative surgery in the prescientific era was regarded as an important therapy within the whole of Medicine. (In this chapter, "Medicine" signifies the totality of the profession, and "medicine" indicates internal medicine as differentiated from surgery, obstetrics, pediatrics, and other specialties.) This seeming paradox, in view of the limited technical appeal of surgery, is explained by the fact that surgical procedures were performed for disorders observable on the surface of the body: There was an "objective" anatomic diagnosis. The men who performed surgical operations saw what needed to be fixed (e.g., inflamed boils, broken bones, bulging tumors, grievous wounds, necrotic digits and limbs, rotten teeth) and treated the problem in as rational a manner as the times permitted.

For individuals who practiced medicine, care was rendered in a more "subjective" manner involving diseases whose etiologies were neither seen nor understood. It is difficult to treat the

symptoms of illnesses such as arthritis, asthma, diabetes, and heart failure when there is no scientific understanding as to what constitutes their pathologic and physiologic underpinnings. It was not until the 19th century and advances in pathologic anatomy and experimental physiology that practitioners of medicine were able to embrace a therapeutic viewpoint more closely approximating that of surgeons. There was no longer a question of treating signs and symptoms in a blind manner. Similar to surgeons who operated on maladies that could be physically described, physicians now cared for patients using clinical details based on "objective" pathophysiologic findings.

Surgeons never needed a diagnostic and pathologic/physiologic revolution in the style of the physician. Despite the imperfection of their knowledge, prescientific surgeons with their unwavering amputation/extirpation approach to treatment sometimes did cure with technical confidence. Notwithstanding their dexterity, it required the spread of the revolution in Medicine during the 1880s and 1890s and the implementation of aseptic techniques along with other soon-to-come discoveries, including the x-ray, blood transfusion, and frozen section, to allow surgeons to emerge as specialists. It would take several more decades, well into the 20th century, for administrative and organizational events to occur before surgery could be considered a bona fide profession.

The explanation for the slow rise of surgery was the protracted elaboration of four key elements (knowledge of anatomy, control of bleeding, control of pain, and control of infection) that were more critical than technical skills when it came to the performance of a surgical procedure. These prerequisites had to be understood and accepted before a surgical operation could be considered a viable therapeutic option. The first two elements started to be addressed in the 16th century, and although surgery greatly benefited from the breakthroughs, its reach was not extended beyond the exterior of the body, and pain and infection continued to be issues for the patient and the surgical operation. Over the ensuing 300 years, there was little further improvement until the discovery of anesthesia in the 1840s and recognition of surgical antisepsis during the 1870s and 1880s. The subsequent blossoming of scientific surgery brought about managerial and socioeconomic initiatives (standardized postgraduate surgical education and training programs; experimental surgical research laboratories; specialty journals, textbooks, monographs, and treatises; and professional societies and licensing organizations) that fostered the concept of professionalism. By the 1950s, the result was a unified profession that was practical and scholarly in nature. Some of the details of the rise of modern surgery follow—specifically how the four key elements that allowed a surgical operation to be viewed as a practical therapeutic choice came to be acknowledged.

KNOWLEDGE OF ANATOMY

Although knowledge of anatomy is the primary requirement of surgery, it was not until the mid-1500s and the height of the European Renaissance that the first great contribution to an understanding of the structure of the human body occurred. This came about when Popes Sixtus IV (1414-1484) and Clement VII (1478-1534) reversed the church's long-standing ban of human dissection and sanctioned the study of anatomy from the cadaver. Andreas Vesalius (1514-1564) (Fig. 1-1) stepped to the forefront of anatomic studies along with his celebrated treatise, *De Humani Corporis Fabrica Libri Septem* (1543). The *Fabrica* broke with the past and provided more detailed descriptions of the human body

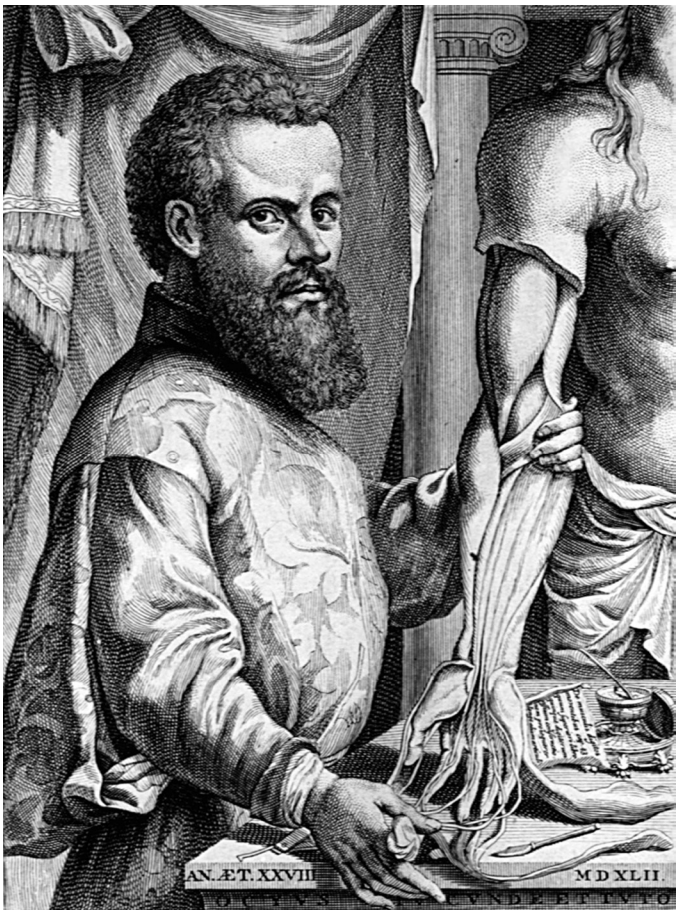


FIGURE 1-1 Andreas Vesalius (1514-1564).

than any of its predecessors. It corrected errors in anatomy that were propagated thousands of years earlier by Greek and Roman authorities, especially Claudius Galen (129-199 AD), whose misleading and later church-supported views were based on animal rather than human dissection. Just as groundbreaking as his anatomic observations was Vesalius' blunt assertion that dissection had to be completed hands-on by physicians themselves. This was a direct repudiation of the long-standing tradition that dissection was a loathsome task to be performed only by individuals in the lower class while the patrician physician sat on high reading out loud from a centuries-old anatomic text.

Vesalius was born in Brussels to a family with extensive ties to the court of the Holy Roman Emperors. He received his medical education in France at universities in Montpellier and Paris and for a short time taught anatomy near his home in Louvain. Following several months' service as a surgeon in the army of Charles V (1500-1558), the 23-year-old Vesalius accepted an appointment as professor of anatomy at the University of Padua in Italy. He remained there until 1544, when he resigned his post to become court physician to Charles V and later to Charles' son, Philip II (1527-1598). Vesalius was eventually transferred to Madrid, but for various reasons, including supposed trouble with authorities of the Spanish Inquisition, he planned a return to his academic pursuits. However, first, in 1563, Vesalius set sail for a year-long pilgrimage to the Holy Land. On his return voyage, Vesalius' ship was wrecked, and he and others were stranded on the small Peloponnesian island of Zakynthos. Vesalius died there as a result of exposure, starvation, and the effects of a severe illness, probably typhoid.

The 7 years that Vesalius spent in Padua left an indelible mark on the evolution of Medicine and especially surgery. His well-publicized human dissections drew large crowds, and Vesalius was in constant demand to provide anatomic demonstrations in other Italian cities, all of which culminated in the publication of the *Fabrica*. Similar to most revolutionary works, the book attracted critics and sympathizers, and the youthful Vesalius was subjected to vitriolic attacks by some of the most renowned anatomists of that era. To his many detractors, the impassioned Vesalius often responded with intemperate counterattacks that did little to further his cause. In one fit of anger, Vesalius burned a trove of his own manuscripts and drawings.

The popularity of Vesalius' *Fabrica* rested on its outstanding illustrations. For the first time, detailed drawings of the human body were closely integrated with an accurate written text. Artists, believed to be from the school of Titian (1477-1576) in Venice, produced pictures that were scientifically accurate and creatively beautiful. The woodcuts, with their majestic skeletons and flayed muscled men set against backgrounds of rural and urban landscapes, became the standard for anatomic texts for several centuries.

The work of Vesalius paved the way for wide-ranging research into human anatomy, highlighted by a fuller understanding of the circulation of blood. In 1628, William Harvey (1578-1657) showed that the heart acts as a pump and forces blood along the arteries and back via veins, forming a closed loop. Although not a surgeon, Harvey's research had enormous implications for the evolution of surgery, particularly its relationship with anatomy and the conduct of surgical operations. As a result, in the 17th century, links between anatomy and surgery intensified as skilled surgeon-anatomists arose.

During the 18th century and first half of the 19th century, surgeon-anatomists made some of their most remarkable observations. Each country had its renowned individuals: In The Netherlands were Govard Bidloo (1649-1713), Bernhard Siegfried Albinus (1697-1770), and Pieter Camper (1722-1789); Albrecht von Haller (1708-1777), August Richter (1742-1812), and Johann Friedrich Meckel (1781-1833) worked in Germany; Antonio Scarpa (1752-1832) worked in Italy; and in France, Pierre-Joseph Desault (1744-1795), Jules Cloquet (1790-1883), and Alfred Armand Louis Marie Velpeau (1795-1867) were the most well known. Above all, however, were the efforts of numerous British surgeon-anatomists who established a well-deserved tradition of excellence in research and teaching.

William Cowper (1666-1709) was one of the earliest and best known of the English surgeon-anatomists, and his student, William Cheselden (1688-1752), established the first formal course of instruction in surgical anatomy in London in 1711. In 1713, *Anatomy of the Human Body* by Cheselden was published and became so popular that it went through at least 13 editions. Alexander Monro *(primus)* (1697-1767) was Cheselden's mentee and later established a center of surgical-anatomic teaching in Edinburgh, which was eventually led by his son Alexander (*secundus*) (1737-1817) and grandson Alexander *(tertius)* (1773-1859). In London, John Hunter (1728-1793) (Fig. 1-2), who is considered among the greatest surgeons of all time, gained fame as a comparative anatomist-surgeon, while his brother, William Hunter (1718-1783), was a successful obstetrician who authored the acclaimed atlas, *Anatomy of the Human Gravid Uterus* (1774). Another brother duo, John Bell (1763-1820) and Charles Bell (1774-1842), worked in Edinburgh and London, where their exquisite anatomic engravings exerted a lasting influence. By the middle of the 19th century, surgical anatomy as a scientific discipline was well established. However, as surgery evolved into a more demanding profession, the anatomic atlases and illustrated surgical textbooks were less likely to be written by the surgeon-anatomist and instead were written by the full-time anatomist.

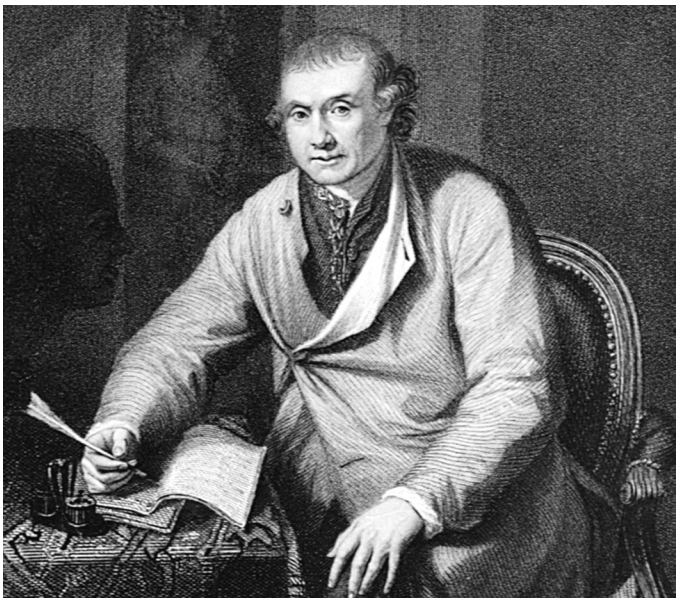


FIGURE 1-2 John Hunter (1728-1793).

FIGURE 1-3 Ambroise Paré (1510-1590).

CONTROL OF BLEEDING

Although Vesalius brought about a greater understanding of human anatomy, one of his contemporaries, Ambroise Paré (1510-1590) (Fig. 1-3), proposed a method to control hemorrhage during a surgical operation. Similar to Vesalius, Paré is important to the history of surgery because he also represents a

severing of the final link between the surgical thoughts and techniques of the ancients and the push toward a more modern era. The two men were acquaintances, both having been summoned to treat Henry II (1519-1559), who sustained what proved to be a fatal lance blow to his head during a jousting match.

Paré was born in France and, at an early age, apprenticed to a series of itinerant barber-surgeons. He completed his indentured education in Paris, where he served as a surgeon's assistant/wound dresser in the famed Hôtel Dieu. From 1536 until just before his death, Paré worked as an army surgeon (he accompanied French armies on their military expeditions), while also maintaining a civilian practice in Paris. Paré's reputation was so great that four French kings, Henry II, Francis II (1544-1560), Charles IX (1550-1574), and Henry III (1551-1589) selected him as their surgeon-in-chief. Despite being a barber-surgeon, Paré was eventually made a member of the Paris-based College of St. Côme, a self-important fraternity of university-educated physician/surgeons. On the strength of Paré's personality and enormity of his clinical triumphs, a rapprochement between the two groups ensued, which set a course for the rise of surgery in France.

In Paré's time, applications of a cautery or boiling oil or both were the most commonly employed methods to treat a wound and control hemorrhage. Their use reflected belief in a medical adage dating back to the age of Hippocrates: Those diseases that medicines do not cure, iron cures; those that iron cannot cure, fire cures; and those that fire cannot cure are considered incurable. Paré changed such thinking when, on a battlefield near Turin, his supply of boiling oil ran out. Not knowing what to do, Paré blended a concoction of egg yolk, rose oil (a combination of ground-up rose petals and olive oil), and turpentine and treated the remaining injured. Over the next several days, he observed that the wounds of the soldiers dressed with the new mixture were neither as inflamed nor as tender as the wounds treated with hot oil. Paré abandoned the use of boiling oil not long afterward.

Paré sought other approaches to treat wounds and staunch hemorrhage. His decisive answer was the ligature, and its introduction proved a turning point in the evolution of surgery. The early history of ligation of blood vessels is shrouded in uncertainty, and whether it was the Chinese and Egyptians or the Greeks and Romans who first suggested the practice is a matter of historical conjecture. One thing is certain: The technique was long forgotten, and Paré considered his method of ligation during an amputation to be original and nothing short of divine inspiration. He even designed a predecessor to the modern hemostat, a pinching instrument called the bec de corbin, or "crow's beak," to control bleeding while the vessel was handled.

As with many ground-breaking ideas, Paré's suggestions regarding ligatures were not readily accepted. The reasons given for the slow embrace range from a lack of skilled assistants to help expose blood vessels to the large number of instruments needed to achieve hemostasis—in preindustrial times, surgical tools were handmade and expensive to produce. The result was that ligatures were not commonly used to control bleeding, especially during an amputation, until other devices were available to provide temporary hemostasis. This did not occur until the early 18th century when Jean-Louis Petit (1674-1750) invented the screw compressor tourniquet. Petit's device placed direct pressure over the main artery of the extremity to be amputated and provided the short-term control of bleeding necessary to allow the accurate placement of ligatures. Throughout the remainder of the 18th and 19th centuries, the use of new types of sutures and tourniquets increased in tandem as surgeons attempted to ligate practically every blood vessel in the body. Nonetheless, despite the abundance of elegant instruments and novel suture materials (ranging from buckskin to horsehair), the satisfactory control of bleeding, especially in delicate surgical operations, remained problematic.

Starting in the 1880s, surgeons began to experiment with electrified devices that could cauterize. These first-generation electrocauteries were ungainly machines, but they did quicken the conduct of a surgical operation. In 1926, Harvey Cushing (1869-1939), professor of surgery at Harvard, experimented with a less cumbersome surgical device that contained two separate electric circuits, one to incise tissue without bleeding and the other simply to coagulate. The apparatus was designed by a physicist, William Bovie (1881-1958), and the two men collaborated to develop interchangeable metal tips, steel points, and wire loops that could be attached to a sterilizable pistol-like grip used to direct the electric current. As the electrical and engineering snags were sorted out, the Bovie electroscalpel became an instrument of trailblazing promise; almost a century later, it remains a fundamental tool in the surgeon's armamentarium.

CONTROL OF PAIN

In the prescientific era, the inability of surgeons to perform pain-free operations was among the most terrifying dilemmas of Medicine. To avoid the horror of the surgeon's merciless knife, patients often refused to undergo a needed surgical operation or repeatedly delayed the event. That is why a scalpel wielder was more concerned about the speed with which he could complete a procedure than the effectiveness of the dissection. Narcotic and soporific agents, such as hashish, mandrake, and opium, had been used for thousands of years, but all were for naught. Nothing provided any semblance of freedom from the misery of a surgical operation. This was among the reasons why the systematic surgical exploration of the abdomen, cranium, joints, and thorax had to wait.

As anatomic knowledge and surgical techniques improved, the search for safe methods to render a patient insensitive to pain became more pressing. By the mid-1830s, nitrous oxide had been discovered, and so-called laughing gas frolics were coming into vogue as young people amused themselves with the pleasant side effects of this compound. After several sniffs, individuals lost their sense of equilibrium, carried on without inhibition, and felt little discomfort as they clumsily knocked into nearby objects. Some physicians and dentists realized that the pain-relieving qualities of nitrous oxide might be applicable to surgical operations and tooth extractions.

A decade later, Horace Wells (1815-1848), a dentist from Connecticut, had fully grasped the concept of using nitrous oxide for inhalational anesthesia. In early 1845, he traveled to Boston to share his findings with a dental colleague, William T.G. Morton (1819-1868), in the hopes that Morton's familiarity with the city's medical elite would lead to a public demonstration of painless tooth-pulling. Morton introduced Wells to John Collins Warren (1778-1856), professor of surgery at Harvard, who invited the latter to show his discovery before a class of medical students, one of whom volunteered to have his tooth extracted. Wells administered the gas and grasped the tooth. Suddenly, the supposedly anesthetized student screamed in pain. An uproar ensued as catcalls and laughter broke out. A disgraced Wells fled the room followed by several bystanders who hollered at him that the entire spectacle was a "humbug affair." For Wells, it was too much to

bear. He returned to Hartford and sold his house and dental practice.

However, Morton understood the practical potential of Wells' idea and took up the cause of pain-free surgery. Uncertain about the reliability of nitrous oxide, Morton began to test a compound that one of his medical colleagues, Charles T. Jackson (1805-1880), suggested would work better as an inhalational anesthetic—sulfuric ether. Armed with this advice, Morton studied the properties of the substance while perfecting his inhalational techniques. In fall 1846, Morton was ready to demonstrate the results of his experiments to the world and implored Warren to provide him a public venue. On October 16, with the seats of the operating amphitheater of Massachusetts General Hospital filled to capacity, a tense Morton, having anesthetized a 20-year-old man, turned to Warren and told him that all was ready. The crowd was silent and set their gaze on the surgeon's every move. Warren grabbed a scalpel, made a 3-inch incision, and excised a small vascular tumor on the patient's neck. For 25 minutes, the spectators watched in stunned disbelief as the surgeon performed a painless surgical operation.

Whether the men in the room realized that they had just witnessed one of the most important events in Medical history is unknown. An impressed Warren, however, slowly uttered the five most famous words in American surgery: "Gentlemen, this is no humbug." No one knew what to do or say. Warren turned to his patient and repeatedly asked him whether he felt anything. The answer was a definitive no—no pain, no discomfort, nothing at all. Few medical discoveries have been so readily accepted as inhalational anesthesia. News of the momentous event spread swiftly as a new era in the history of surgery began. Within months, sulfuric ether and another inhalational agent, chloroform, were used in hospitals worldwide.

The acceptance of inhalational anesthesia fostered research on other techniques to achieve pain-free surgery. In 1885, William Halsted (1852-1922) (Fig. 1-4), professor of surgery at the Johns Hopkins Hospital in Baltimore, announced that he had used cocaine and infiltration anesthesia (nerve-blocking) with great success in more than 1000 surgical cases. At the same time, James Corning (1855-1923) of New York carried out the earliest experiments on spinal anesthesia, which were soon expanded on by August Bier (1861-1939) of Germany. By the late 1920s, spinal anesthesia and epidural anesthesia were widely used in the United States and Europe. The next great advance in pain-free surgery occurred in 1934, when the introduction of an intravenous anesthetic agent (sodium thiopental [Sodium Pentothal]) proved tolerable to patients, avoiding the sensitivity of the tracheobronchial tree to anesthetic vapors.

CONTROL OF INFECTION

Anesthesia helped make the potential for surgical cures more seductive. Haste was no longer of prime concern. However, no matter how much the discovery of anesthesia contributed to the relief of pain during surgical operations, the evolution of surgery could not proceed until the problem of postoperative infection was resolved. If ways to deaden pain had never been conceived, a surgical procedure could still be performed, although with much difficulty. Such was not the case with infection. Absent antisepsis and asepsis, surgical procedures were more likely to end in death rather than just pain.

In the rise of modern surgery, several individuals and their contributions stand out as paramount. Joseph Lister (1827-1912) (Fig. 1-5), an English surgeon, belongs on this select list for his efforts to control surgical infection through antisepsis. Lister's research was based on the findings of the French chemist Louis Pasteur (1822-1895), who studied the process of fermentation and showed that it was caused by the growth of living microorganisms. In the mid-1860s, Lister hypothesized that these invisible

FIGURE 1-4 William Halsted (1852-1922).

FIGURE 1-5 Joseph Lister (1827-1912).

"germs," or, as they became known, bacteria, were the cause of wound healing difficulties in surgical patients. He proposed that it was feasible to prevent suppuration by applying an antibacterial solution to a wound and covering the site in a dressing saturated with the same germicidal liquid.

Lister was born into a well-to-do Quaker family from London. In 1848, he received his medical degree from University College. Lister was appointed a fellow of the Royal College of Surgeons 4 years later. He shortly moved to Edinburgh, where he became an assistant to James Syme (1799-1870). Their mentor/mentee relationship was strengthened when Lister married Syme's daughter Agnes (1835-1896). At the urging of his father-in-law, Lister applied for the position of professor of surgery in Glasgow. The 9 years that he spent there were the most important period in Lister's career as a surgeon-scientist.

In spring 1865, a colleague told Lister about Pasteur's research on fermentation and putrefaction. Lister was one of the few surgeons of his day who, because of his familiarity with the microscope (his father designed the achromatic lens and was one of the founders of modern microscopy), had the ability to understand Pasteur's findings about microorganisms on a first-hand basis. Armed with this knowledge, Lister showed that an injury was already full of bacteria by the time the patient arrived at the hospital.

Lister recognized that the elimination of bacteria by excessive heat could not be applied to a patient. Instead, he turned to chemical antisepsis and, after experimenting with zinc chloride and sulfites, settled on carbolic acid (phenol). By 1866, Lister was instilling pure carbolic acid into wounds and onto dressings and spraying it into the atmosphere around the operative field and table. The following year, he authored a series of papers on his experience in which he explained that pus in a wound (these were the days of "laudable pus," when it was mistakenly believed the more suppuration the better) was not a normal part of the healing process. Lister went on to make numerous modifications in his technique of dressings, manner of applying them, and choice of antiseptic solutions—carbolic acid was eventually abandoned in favor of other germicidal substances. He did not emphasize hand scrubbing but merely dipped his fingers into a solution of phenol and corrosive sublimate. Lister was incorrectly convinced that scrubbing created crevices in the palms of the hands where bacteria would proliferate.

A second major advance by Lister was the development of sterile absorbable sutures. Lister believed that much of the suppuration found in wounds was created by contaminated ligatures. To prevent the problem, Lister devised an absorbable suture impregnated with phenol. Because it was not a permanent ligature, he was able to cut it short, closing the wound tightly and eliminating the necessity of bringing the ends of the suture out through the incision, a surgical practice that had persisted since the days of Paré.

For many reasons, the acceptance of Lister's ideas about infection and antisepsis was an uneven and slow process. First, the various procedural changes that Lister made during the evolution of his method created confusion. Second, listerism, as a technical exercise, was complicated and time-consuming. Third, early attempts by other surgeons to use antisepsis were abject failures. Finally, and most importantly, acceptance of listerism depended on an understanding of the germ theory, a hypothesis that many practical-minded scalpel wielders were loath to recognize.

As a professional group, German-speaking surgeons were the earliest to grasp the importance of bacteriology and Lister's ideas. In 1875, Richard von Volkmann (1830-1889) and Johann Nussbaum (1829-1890) commented favorably on their treatment of compound fractures with antiseptic methods. In France, Just Lucas-Championière (1843-1913) was not far behind. The following year, Lister traveled to the United States, where he spoke at the International Medical Congress held in Philadelphia and gave additional lectures in Boston and New York. Lister's presentations were memorable, sometimes lasting more than 3 hours, but American surgeons remained unconvinced about his message. American surgeons did not begin to embrace the principles of antisepsis until the mid-1880s. The same was also true in Lister's home country, where he initially encountered strong opposition led by the renowned gynecologist Lawson Tait (1845-1899).

Over the years, Lister's principles of antisepsis gave way to principles of asepsis, or the complete elimination of bacteria. The concept of asepsis was forcefully advanced by Ernst von Bergmann (1836-1907), professor of surgery in Berlin, who recommended steam sterilization (1886) as the ideal method to eradicate germs. By the mid-1890s, less clumsy antiseptic and aseptic techniques had found their way into most American and European surgical amphitheaters. Any lingering doubts about the validity of Lister's concepts of wound infection were eliminated on the battlefields of World War I. Aseptic technique was virtually impossible to attain on the battlefield, but the invaluable principle of wound treatment by means of surgical débridement and mechanical irrigation with an antiseptic solution was developed by Alexis Carrel (1873-1944) (Fig. 1-6), the Nobel prize-winning French-American surgeon, and Henry Dakin (1880-1952), an English chemist.

Once antiseptic and aseptic techniques had been accepted as routine elements of surgical practice, it was inevitable that other antibacterial rituals would take hold, in particular, the use of caps, hats, masks, drapes, gowns, and rubber gloves. Until the 1870s, surgeons did not use gloves because the concept of bacteria on the hands was not recognized. In addition, no truly functional glove had ever been designed. This situation changed in 1878, when an employee of the India-Rubber Works in Surrey, England, received British and U.S. patents for the manufacture of a surgical glove

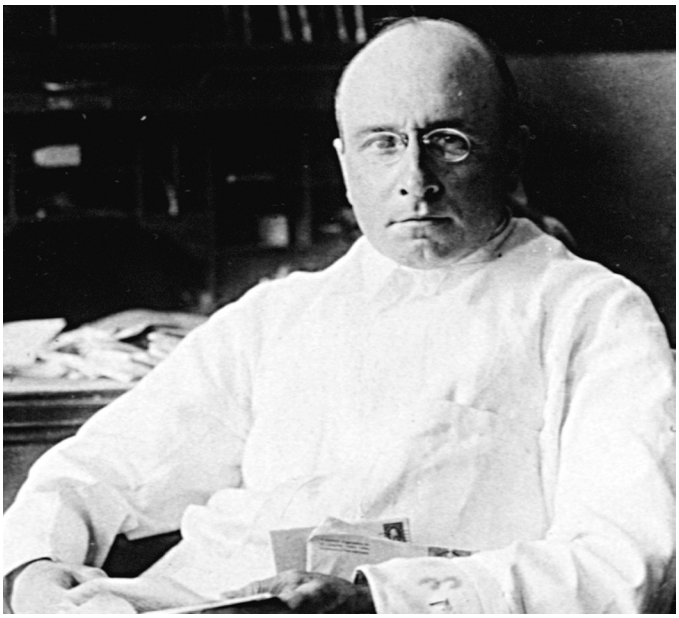


FIGURE 1-6 Alexis Carrel (1873-1944).

that had a "delicacy of touch." The identity of the first surgeon who required that flexible rubber gloves be consistently worn for every surgical operation is uncertain. Halsted is regarded as the individual who popularized their use, although the idea of rubber gloves was not fully accepted until the 1920s.

In 1897, Jan Mikulicz-Radecki (1850-1905), a Polish-Austrian surgeon, devised a single-layer gauze mask to be worn during a surgical operation. An assistant modified the mask by placing two layers of cotton-muslin onto a large wire frame to keep the gauze away from the surgeon's lips and nose. This modification was crucial because a German microbiologist showed that bacteria-laden droplets from the mouth and nose enhanced the likelihood of wound infection. Silence in the operating room became a cardinal feature of surgery in the early 20th century. At approximately the same time, when it was also determined that masks provided less protection if an individual was bearded, the days of surgeons sporting bushy beards and droopy mustaches went by the wayside.

OTHER ADVANCES THAT FURTHERED THE RISE OF MODERN SURGERY

X-Rays

Most prominent among other advances that furthered the rise of modern surgery was the discovery by Wilhelm Roentgen (1845-1923) of x-rays. He was professor of physics at Würzburg University in Germany, and in late December 1895, he presented to that city's medical society a paper on electromagnetic radiation. Roentgen was investigating the photoluminescence from metallic salts that had been exposed to light when he noticed a greenish glow coming from a screen painted with a phosphorescent substance located on a shelf over nine feet away. He came to realize there were invisible rays (he termed them *x-rays*) capable of passing through objects made of wood, metal, and other materials. Significantly, these rays also penetrated the soft tissues of the body in such a way that more dense bones were revealed on a specially treated photographic plate. Similar to the discovery of inhalational anesthesia, the importance of x-rays was realized immediately. By March 1896, the first contributions regarding the use of roentgenography in the practice of Medicine in the United States were reported. In short order, numerous applications were developed as surgeons rapidly applied the new finding to the diagnosis and location of dislocations and fractures, the removal of foreign bodies, and the treatment of malignant tumors.

Blood Transfusion

Throughout the late 19th century, there were scattered reports of blood transfusions, including one by Halsted on his sister for postpartum hemorrhage with blood drawn from his own veins. However, it was not until 1901, when Karl Landsteiner (1868-1943), an Austrian physician, discovered the major human blood groups, that blood transfusion became a less risky practice. George Crile (1864-1943), a noted surgeon from Cleveland, performed the first surgical operation during which a blood transfusion was used and the patient survived 5 years later.

The development of a method to make blood noncoagulable was the final step needed to ensure that transfusions were readily available. This method was developed in the years leading up to World War I when Richard Lewisohn (1875-1962) of New York and others showed that by adding sodium citrate and glucose as an anticoagulant and refrigerating the blood, it could be stored for several days. Once this was known, blood banking became feasible as demonstrated by Geoffrey Keynes (1887-1982), a noted British surgeon (and younger brother of the famed economist John Maynard Keynes), who built a portable cold-storage unit that enabled transfusions to be carried out on the battlefield. In 1937, Bernard Fantus (1874-1940), director of the pharmacology and therapeutics department at Cook County Hospital in Chicago, took the concept of storing blood one step further when he established the first hospital-based "blood bank" in the United States.

FIGURE 1-7 Charles Drew (1904-1950).

Despite the success in storing and crossmatching blood, immune-related reactions persisted. In this regard, another important breakthrough came in 1939, when Landsteiner identified the Rh factor (so named because of its presence in the rhesus monkey). At the same time, Charles Drew (1904-1950) (Fig. 1-7), a surgeon working at Columbia University, showed how blood could be separated into two main components, red blood cells and plasma, and that the plasma could be frozen for long-term storage. His discovery led to the creation of large-scale blood banking, especially for use by the military during World War II. The storing of blood underwent further refinement in the early 1950s when breakable glass bottles were replaced with durable plastic bags.

Frozen Section

The introduction of anesthesia and asepsis allowed surgeons to perform more technically demanding surgical operations. It also meant that surgeons had to refine their diagnostic capabilities. Among the key additions to their problem-solving skills was the technique of frozen section, an innovation that came to be regarded as one of the benchmarks of scientific surgery. In the late 19th century and early years of the 20th century, "surgical pathology" consisted of little more than a surgeon's knowledge of gross pathology and his ability to recognize lesions on the surface of the

FIGURE 1-8 Theodor Billroth (1829-1894).

body. Similar to the notion of the surgeon-anatomist, the surgeon-pathologist, exemplified by James Paget (1814-1899) of London and the renowned Theodor Billroth (1829-1894) (Fig. 1-8) of Vienna, authored the major textbooks and guided the field.

In 1895, Nicholas Senn (1844-1908), professor of pathology and surgery at Rush Medical College in Chicago, recommended that a "freezing microtome" be used as an aid in diagnosis during a surgical operation. However, the early microtomes were crude devices, and freezing led to unacceptable distortions in cellular morphology. This situation was remedied as more sophisticated methods for hardening tissue evolved, particularly systems devised by Thomas Cullen (1868-1953), a gynecologist at the Johns Hopkins Hospital, and Leonard Wilson (1866-1943), chief of pathology at the Mayo Clinic. During the late 1920s and early 1930s, a time when pathology was receiving recognition as a specialty within Medicine and the influence of the surgeon-pathologist was on the decline, the backing by Joseph Bloodgood (1867-1935), a distinguished surgeon from Baltimore and one of Halsted's earliest trainees, led to the routine use of frozen section during a surgical operation.

ASCENT OF SCIENTIFIC SURGERY

By the first decades of the 20th century, the interactions of politics, science, socioeconomics, and technical advances set the stage for what would become a spectacular showcasing of the progress of surgery. Surgeons wore antiseptic-appearing white caps, gowns, and masks. Patients donned white robes, operating tables were draped in white cloth, and instruments were bathed in white metal basins that contained new and improved antiseptic solutions. All was clean and tidy, with the conduct of the surgical operation no longer a haphazard affair. So great were the innovations that the foundation of basic surgical procedures, including procedures involving the abdomen, cranium, joints, and thorax, was completed by the end of World War I (1918). This transformation was successful not only because surgeons had fundamentally changed but also because Medicine and its relationship to science had been irrevocably altered. Sectarianism and quackery, the consequences of earlier medical dogmatism, were no longer tenable within the confines of scientific inquiry.

Nonetheless, surgeons retained a lingering sense of professional and social discomfort and continued to be pejoratively described by some physicians as nonthinkers who worked in an inferior manual craft. The result was that scalpel bearers had no choice but to allay the fear and misunderstanding of the surgical unknown of their colleagues and the public by promoting surgical procedures as an acceptable part of the new armamentarium of Medicine. This was not an easy task, particularly because the negative consequences of surgical operations, such as discomfort and complications, were often of more concern to patients than the positive knowledge that devastating disease processes could be thwarted.

It was evident that theoretical concepts, research models, and clinical applications were necessary to demonstrate the scientific basis of surgery. The effort to devise new surgical operations came to rely on experimental surgery and the establishment of surgical research laboratories. In addition, an unimpeachable scientific basis for surgical recommendations, consisting of empirical data collected and analyzed according to nationally and internationally accepted standards and set apart from individual assumptions, had to be developed. Surgeons also needed to demonstrate managerial and organizational unity, while conforming to contemporary cultural and professional norms.

These many challenges involved new administrative initiatives, including the establishment of self-regulatory and licensing bodies. Surgeons showed the seriousness of their intent to be viewed as specialists within the mainstream of Medicine by establishing standardized postgraduate surgical education and training programs and professional societies. In addition, a new type of dedicated surgical literature appeared: specialty journals to disseminate news of surgical research and technical innovations promptly. The result of these measures was that the most consequential achievement of surgeons during the mid-20th century was ensuring the social acceptability of surgery as a legitimate scientific endeavor and the surgical operation as a bona fide therapeutic necessity.

The history of the socioeconomic transformation and professionalization of modern surgery varied from country to country. In Germany, the process of economic and political unification under Prussian dominance presented new and unlimited opportunities for physicians and surgeons, particularly when government officials decreed that more than a simple medical degree was necessary for the right to practice. A remarkable scholastic achievement occurred in the form of the richly endowed state-sponsored university where celebrated professors of surgery administered an impressive array of surgical training programs (other medical disciplines enjoyed the same opportunities). The national achievements of German-speaking surgeons soon became international, and from the 1870s through World War I, German universities were the center of world-recognized surgical excellence.

The demise of the status of Austria-Hungary and Germany as the global leader in surgery occurred with the end of the World War I. The conflict destroyed much of Europe—if not its physical features, then a large measure of its passion for intellectual and

scientific pursuits. The result was that a vacuum existed internationally in surgical education, research, and therapeutics. It was only natural that surgeons from the United States, the industrialized nation least affected psychologically and physically by the outcome of the war, would fill this void. So began the ascent of American surgery to its current position of worldwide leadership. Some details about the transformation and professionalization of modern American surgery follow.

Standardized Postgraduate Surgical Education and Training Programs

For the American surgeon of the late 19th century, any attempt at formal learning was a matter of personal will with limited practical opportunities. There were a few so-called teaching hospitals but no full-time academic surgeons. To study surgery in these institutions consisted of assisting surgeons in their daily rounds and observing the performance of surgical operations; there was minimal hands-on operative experience. Little, if any, integration of the basic sciences with surgical diagnosis and treatment took place. In the end, most American surgeons were self-taught and, consequently, not eager to hand down hard-earned and valuable skills to younger men who were certain to become competitors.

Conversely, the German system of surgical education and training brought the basic sciences together with practical clinical teaching coordinated by full-time academicians. There was a competitiveness among the young surgeons-in-training that began in medical school with only the smartest and strongest willed being rewarded. At the completion of an internship, which usually included a stint in a basic science laboratory, the young physician would, if fortunate, be asked to become an assistant to a professor of surgery. At this point, the surgeon-to-be was thrust into the thick of an intense contest to become the first assistant (called the chief resident today). There was no regular advancement from the bottom to the top of the staff, and only a small number ever became the first assistant. The first assistant would hold his position until called to a university's chair of surgery or until he tired of waiting and went into practice. From this labyrinth of education and training programs, great surgeons produced more great surgeons, and these men and their schools of surgery offered Halsted the inspiration and philosophies he needed to establish an American system of education and training in surgery.

Halsted was born into a well-to-do New York family and received the finest educational opportunities possible. He had private elementary school tutors, attended boarding school at Phillips Andover Academy, and graduated from Yale in 1874. Halsted received his medical degree 3 years later from the College of Physicians and Surgeons in New York (now Columbia University) and went on to serve an 18-month internship at Bellevue Hospital. With the accomplishments of the German-speaking medical world attracting tens of thousands of American physicians to study abroad, Halsted joined the pilgrimage and spent 1878 through 1880 at universities in Berlin, Hamburg, Kiel, Leipzig, Vienna, and Würzburg. He could not help but notice the stark difference between the German and American manner of surgical education and training.

The surgical residency system that Halsted implemented at the Johns Hopkins Hospital in 1889 was a consolidation of the German approach. In his program, the first of its kind in the United States, Halsted insisted on a more clearly defined pattern of organization and division of duties. The residents had a larger volume of operative material at their disposal, a more intimate contact with practical clinical problems, and a graduated concentration of clinical authority and responsibility in themselves rather than the professor. Halsted's aim was to train outstanding surgical teachers, not merely competent operating surgeons. He showed his residents that research based on anatomic, pathologic, and physiologic principles, along with animal experimentation, made it possible to develop sophisticated operative procedures.

Halsted proved, to an often leery profession and public, that an unambiguous sequence of discovery to implementation could be observed between the experimental research laboratory and the clinical operating room. In so doing, he developed a system of surgery so characteristic that it was termed a "school of surgery." More to the point, Halsted's principles of surgery became a widely acknowledged and accepted scientific imprimatur. More than any other surgeon, it was the aloof and taciturn Halsted, who moved surgery from the melodramatics and grime of the 19th century surgical theater to the silence and cleanliness of the 20th century operating room.

Halsted is regarded as "Adam" in American surgery, but he trained only 17 chief residents. The reason for this was that among the defining features of Halsted's program was an indefinite time of tenure for his first assistant. Halsted insisted that just one individual should survive the steep slope of the residency pyramid and only every few years. Of these men, several became professors of surgery at other institutions where they began residency programs of their own, including Harvey Cushing at Harvard, Stephen Watts (1877-1953) at Virginia, George Heuer (1882-1950) and Mont Reid (1889-1943) at Cincinnati, and Roy McClure (1882-1951) at Henry Ford Hospital in Detroit. By the 1920s, there were a dozen or so Halsted-style surgical residencies in the United States. However, the strict pyramidal aspect of the Halsted plan was so self-limiting (i.e., one first assistant/chief resident with an indefinite length of appointment) that in an era when thousands of physicians clamored to be recognized as specialists in surgery, his restrictive style of surgical residency was not widely embraced. For that reason, his day-to-day impact on the number of trained surgeons was less significant than might be thought.

There is no denying that Halsted's triad of educational principles—knowledge of the basic sciences, experimental research, and graduated patient responsibility—became a preeminent and permanent feature of surgical training programs in the United States. However, by the end of World War II, most surgical residencies were organized around the less severe rectangular structure of advancement employed by Edward Churchill (1895-1972) at the Massachusetts General Hospital beginning in the 1930s. This style of surgical education and training was a response to newly established national standards set forth by the American Medical Association (AMA) and the American Board of Surgery.

In 1920, for the first time, the AMA Council on Medical Education published a list of 469 general hospitals with 3000 "approved" internships. The annual updating of this directory became one of the most important and well-publicized activities of the AMA and provided health care planners with their earliest detailed national database. The AMA expanded its involvement in postgraduate education and training 7 years later when it issued a registry of 1700 approved residencies in various medical and surgical specialties, including anesthesia, dermatology, gynecology and obstetrics, medicine, neuropsychiatry, ophthalmology, orthopedics, otolaryngology, pathology, pediatrics, radiology, surgery, tuberculosis, and urology. By this last action, the AMA publicly

declared support for the concept of specialization, a key policy decision that profoundly affected the professional future of physicians in the United States and the delivery of health care.

Experimental Surgical Research Laboratories

Halsted believed that experimental research provided residents with opportunities to evaluate surgical problems in an analytic fashion, an educational goal that could not be achieved solely by treating patients. In 1895, he organized an operative course on animals to teach medical students how to handle surgical wounds and use antiseptic and aseptic techniques. The classes were popular, and, several years later, Halsted asked Cushing, who had recently completed his residency at Hopkins and then spent time in Europe sharpening his experimental research skills with the future Nobel laureates Theodor Kocher (1841-1917) (Fig. 1-9) and Charles Sherrington (1857-1952), to assume responsibility for managing the operative surgery course as well as his experimental laboratory.

Cushing, the most renowned of Halsted's assistants, was a graduate of Yale College and Harvard Medical School. He would go on to become professor of surgery at Harvard and first surgeon-in-chief of the newly built Peter Bent Brigham Hospital. Cushing's clinical accomplishments are legendary and include describing basophil adenomas of the pituitary gland, discovering the rise in systemic blood pressure that resulted from an increase in intracranial pressure, and devising ether charts for the surgical operating room. Just as impressive are Cushing's many achievements outside the world of medical science, the foremost being a Pulitzer Prize in Biography or Autobiography in 1926 for his two-volume work *Life of Sir William Osler*.

Cushing found the operative surgery classroom space to be limited, and he persuaded university trustees to authorize funds to construct the first animal laboratory for surgical research in the United States, the Hunterian Laboratory of Experimental Medicine, named after the famed Hunter. Halsted demanded the same excellence of performance in his laboratory as in the hospital's operating room, and Cushing assured his mentor that this request would be respected. Similar to Halsted, Cushing was an exacting and demanding taskmaster, and he made certain that the Hunterian, which included indoor and outdoor cages for animals, cordoned-off areas for research projects, and a large central room with multiple operating tables, maintained a rigorous scholarly environment where students learned to think like surgical investigators while acquiring the basics of surgical technique. As for the residents in Halsted's program, time in the Hunterian became an integral part of their surgical education and training.

Other American surgeons at the turn of the century demonstrated an interest in experimental surgical research (Senn's book, *Experimental Surgery*, the first American book on the subject, was published in 1889, and Crile's renowned treatise, *An Experimental Research into Surgical Shock*, was published in 1899), but their scientific investigations were not conducted in as formal a setting as the Hunterian. Cushing went on to use the Hunterian for his own neurosurgical research and later took the concept of a surgical research laboratory to Boston where, several surgical generations later, Joseph Murray (1919-2012), working alongside the Brigham's Moseley Professor of Surgery, Francis D. Moore (1913-2001) (Fig. 1-10), won the 1990 Nobel Prize in Physiology or Medicine for his work on organ and cell transplantation in the treatment of human disease, specifically kidney transplant.

One other American surgeon has been named a Nobel laureate. Charles Huggins (1901-1997) (Fig. 1-11) was born in Canada but graduated from Harvard Medical School and received his surgical training at the University of Michigan. While working at the surgical research laboratory of the University of Chicago, Huggins found that antiandrogenic treatment, consisting of orchiectomy or the administration of estrogens, could produce long-term regression in patients with advanced prostatic cancer.

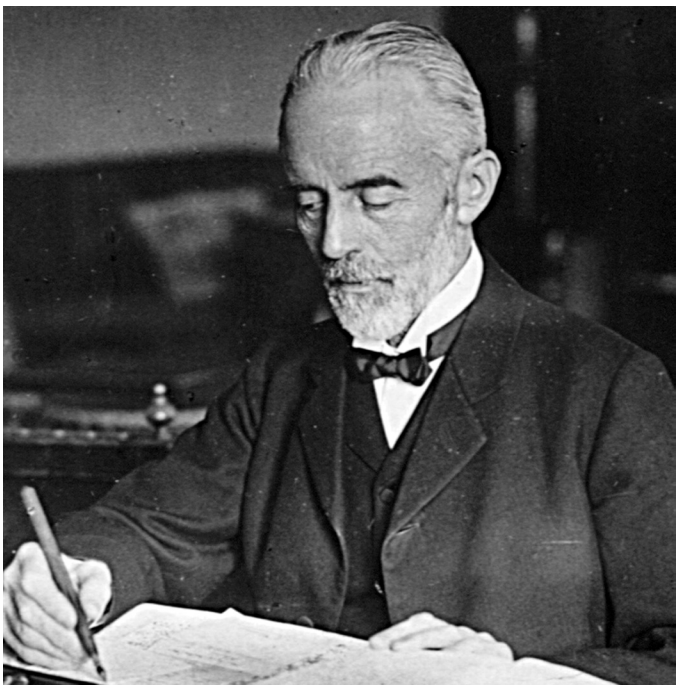


FIGURE 1-9 Theodor Kocher (1841-1917).

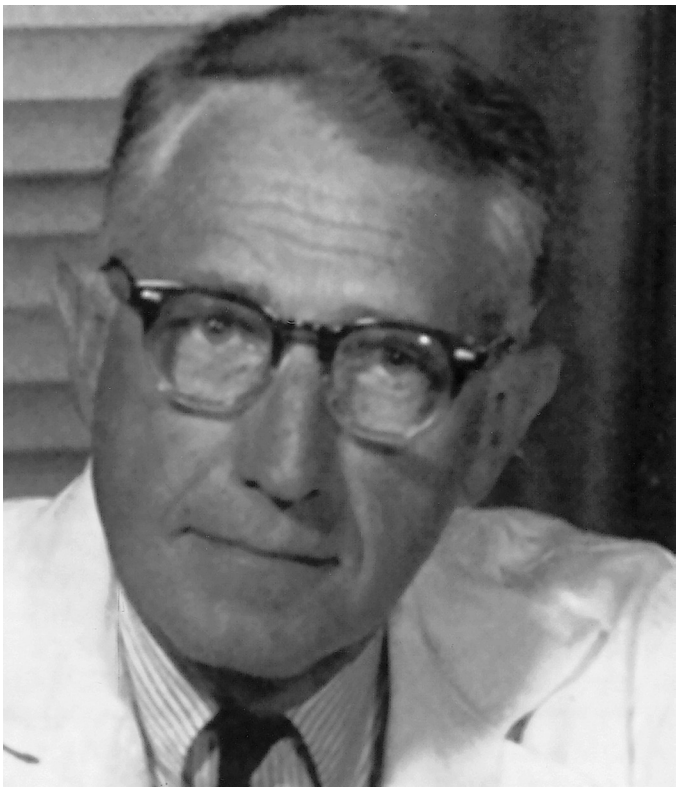


FIGURE 1-10 Francis D. Moore (1913-2001).

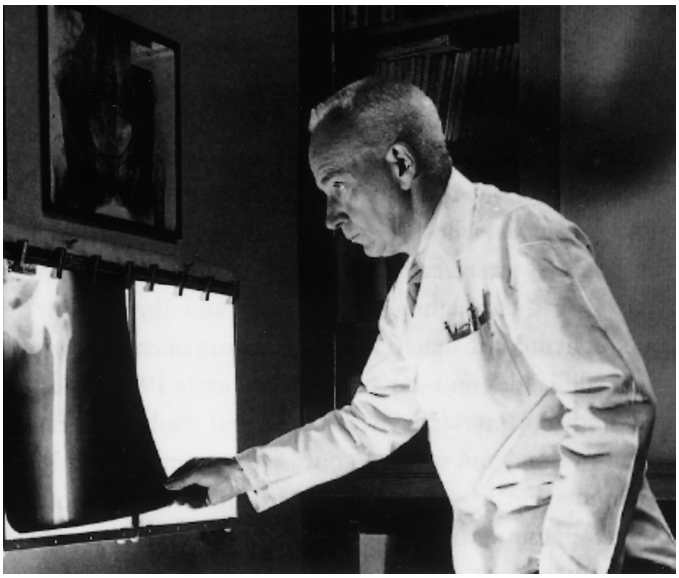


FIGURE 1-11 Charles Huggins (1901-1997).

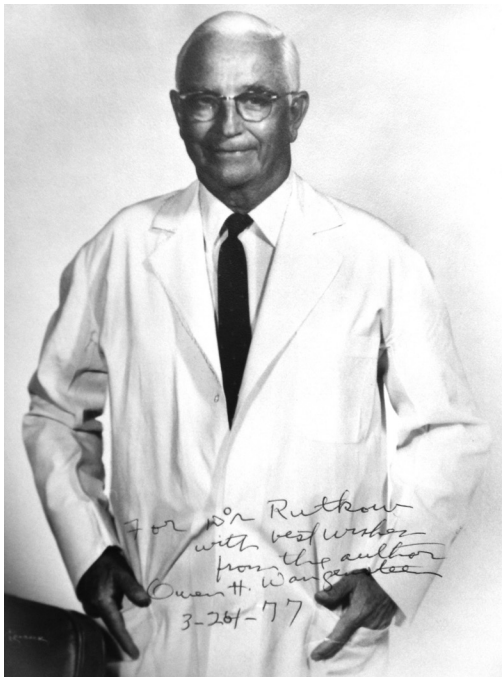


FIGURE 1-12 Owen H. Wangensteen (1898-1981).

These observations formed the basis for the treatment of malignant tumors by hormonal manipulation and led to his receiving the Nobel Prize in Physiology or Medicine in 1966.

Regarding the long-term influence of the Hunterian, it served as a model that was widely embraced by many university hospital officials and surgical residency directors. Thus began a tradition of experimental research that remains a feature of modern American surgical education and training programs, the results of which continue to be seen and heard at the American College of Surgeons Owen H. Wangensteen Forum on Fundamental Surgical Problems, held during the annual Clinical Congress. Owen H. Wangensteen (1898-1981) (Fig. 1-12) was the long-time professor of surgery at the University of Minnesota where he brought his department to prominence as a center for innovative experimental and clinical surgical research.

Specialty Journals, Textbooks, Monographs, and Treatises

Progress in science brought about an authoritative and rapidly growing body of medical and surgical knowledge. The timely dissemination of this information into the clinical practice of surgery became dependent on weekly and monthly medical journals. Physicians in the United States proved adept at promoting this new style of journalism, and by the late 1870s, more health-related periodicals were published in the United States than almost all of Europe. However, most medical magazines were doomed to early failure because of limited budgets and a small number of readers. Despite incorporating the words "Surgery," "Surgical," or "Surgical Sciences" in their masthead, none of these journals treated surgery as a specialty. There were simply not enough physicians who wanted to or could afford to practice surgery around the clock. Physicians were unable to operate with any reasonable anticipation of success until the mid-to-late 1880s and the acceptance of the germ theory and Lister's concepts of antisepsis. Once this occurred, the push toward specialization gathered speed, as numbers of surgical operations increased along with a cadre of full-time surgeons.

For surgeons in the United States, the publication of the *Annals of Surgery* in 1885 marked the beginning of a new era, one guided in many ways by the content of the specialty journal. The *Annals* became intimately involved with the advancement of the surgical sciences, and its pages record the story of surgery in the United States more accurately than any other written source. The magazine remains the oldest continuously published periodical in English devoted exclusively to surgery. Other surgical specialty journals soon appeared, and they, along with the published proceedings and transactions of emerging surgical specialty societies, proved crucial in establishing scientific and ethical guidelines for the profession.

As important as periodicals were to the spread of surgical knowledge, American surgeons also communicated their know-how in textbooks, monographs, and treatises. Similar to the rise of the specialty journal, these massive, occasionally multivolume works first appeared in the 1880s. When David Hayes Agnew (1818-1892), professor of surgery at the University of Pennsylvania, wrote his three-volume, 3000-page *Principles and Practice of Surgery*, he was telling the international surgical world that American surgeons had something to say and were willing to stand behind their words. At almost the same time, John Ashhurst (1839-1900), soon-to-be successor to Agnew at the University of Pennsylvania, was organizing his six-volume *International Encyclopedia of Surgery* (1881-1886), which introduced the concept of a multiauthored surgical textbook. The *Encyclopedia* was an instant publishing success and marked the first time that American and European surgeons worked together as contributors to a surgical text. Ashhurst's effort was shortly joined by Keen's *An American Text-Book of Surgery* (1892), which was the first surgical treatise written by various authorities all of whom were American.

These tomes are the forebears of the present book. In 1936, Frederick Christopher (1889-1967), an associate professor of surgery at Northwestern University and chief surgeon to the Evanston Hospital in Evanston, Illinois, organized a *Textbook of Surgery*. The *Textbook,* which Christopher described as a "cross-sectional presentation of the best in American surgery," quickly became one

FIGURE 1-13 Loyal Davis (1896-1982).

FIGURE 1-14 David Sabiston (1924-2009).

of the most popular of the surgical primers in the United States. He remained in charge for four more editions and, in 1956, was succeeded by Loyal Davis (1896-1982) (Fig. 1-13), professor of surgery at Northwestern University. Davis, who also held a Ph.D. in the neurologic sciences and had studied with Cushing in Boston, was an indefatigable surgical researcher and prolific author. Not only did he edit the sixth, seventh, eighth, and ninth editions of what became known as *Christopher's Textbook of Surgery*, but from 1938 to 1981, Davis also was editor-in-chief of the renowned journal, *Surgery, Gynecology and Obstetrics*. (In the last years of his life, Davis gained further recognition as the father-in-law of President Ronald Reagan.) In 1972, David Sabiston (1924-2009) (Fig. 1-14), professor of surgery at Duke, assumed editorial control of the renamed *Davis-Christopher Textbook of Surgery*. Sabiston was an innovative vascular and cardiac surgeon who held numerous leadership roles throughout his career, including President of the American College of Surgeons, the American Surgical Association, the Southern Surgical Association, and the American Association for Thoracic Surgery. Not only did Sabiston guide editions 10 through 15 of the *Davis-Christopher Textbook*, but he also served as editor-in-chief of the *Annals of Surgery* for 25 years. Starting in 2000 with the 16th edition, Courtney M. Townsend, Jr. (1943-), professor of surgery at the University of Texas Medical Branch in Galveston, took over editorial responsibility for the retitled *Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice*. He has remained in charge through the current 20th edition, and the now legendary work, which Christopher first organized more than 8 decades ago, holds the record for having been updated more times and being the longest lived of any American surgical textbook.

Professional Societies and Licensing Organizations

By the 1920s, surgery was at a point in American society where it was becoming "professionalized." The ascent of scientific surgery had led to technical expertise that gave rise to specialization. However, competence in the surgical operating room alone was not sufficient to distinguish surgery as a profession. Any discipline that looks to be regarded as a profession must assert exclusive control over the expertise of its members and convince the public that these skills are unique and dependable (i.e., act as a monopoly). For the community at large, the notion of trustworthiness is regarded as a fundamental criterion of professional status. To gain and maintain that trust, the professional group has to have complete jurisdiction over its admission policies and be able to discipline and force the resignation of any associate who does not meet rules of acceptable behavior. In their quest for professionalization and specialization, American surgeons created self-regulating professional societies and licensing organizations during the first half of the 20th century.

Around 1910, conflicts between general practitioners and specialists in surgery reached a fever pitch. As surgical operations became more technically sophisticated, inadequately trained or incompetent physicians-cum-surgeons were viewed as endangering patients' lives as well as the reputation of surgery as a whole. That year, Abraham Flexner (1866-1959) issued his now famous report that reformed medical education in the United States. Much as Flexner's manifesto left an indelible mark on more progressive and trustworthy medical schooling, the establishment of the American College of Surgeons 3 years later was meant to impress on general practitioners the limits of their surgical abilities and to show the public that a well-organized group of specialist surgeons could provide dependable and safe operations.

The founding of the American College of Surgeons fundamentally altered the course of surgery in the United States. Patterned after the Royal Colleges of Surgeons of England, Ireland, and Scotland, the American College of Surgeons established professional, ethical, and moral guidelines for every physician who practiced surgery and conferred the designation Fellow of the American College of Surgeons (FACS) on its members. For the first time, there was a national organization that united surgeons by exclusive membership in common educational, socioeconomic, and political causes. Although the American Surgical Association

had been founded more than 3 decades earlier, it was composed of a small group of elite senior surgeons and was not meant to serve as a national lobbying front. There were also regional surgical societies, including the Southern Surgical Association (1887) and the Western Surgical Association (1891), but they had less restrictive membership guidelines than the American College of Surgeons, and their geographic differences never brought about national unity.

Because the integrity of the medical profession is largely assured by the control it exercises over the competency of its members, the question of physician licensing and limits of specialization, whether mandated by the government or by voluntary self-regulation, became one of crucial importance. State governments had begun to establish stricter licensing standards, but their statutes did not adequately delineate generalist from specialist. This lack of rules and regulations for specialty practice was a serious concern. Leaders in Medicine realized that if the discipline did not move to regulate specialists, either federal or state agencies would be forced to fill this role, a situation that few physicians wanted. There was also lay pressure. Patients, increasingly dependent on physicians for scientific-based medical and surgical care, could not determine who was qualified to do what—state licensure only established a minimum standard, and membership in loosely managed professional societies revealed little about competency.

By the end of World War I, most surgical (and medical) specialties had established nationally recognized fraternal organizations, such as the American College of Surgeons. In the case of the American College of Surgeons, although its founders hoped to distinguish full-time surgeons from general practitioners, the organization initially set membership guidelines low in its haste to expand enrollment—10 years after its creation, there were more than 7000 Fellows. The American College of Surgeons emphasized an applicant's ability to perform a surgical operation and was less concerned about the depth of overall medical knowledge that sustained an individual's surgical judgment. Furthermore, membership did not depend on examinations or personal interviews. Despite these flaws, the American College of Surgeons did begin to clarify the concept of a surgical specialist to the public. The sheer presence of the American College of Surgeons implied that full-time surgeons outperformed general practitioners and their part-time approach to surgery, while reinforcing the professional authority and clinical expertise of the surgical specialist.

Even with the presence of organizations such as the American College of Surgeons, without a powerful centralized body to coordinate activities, attempts to regulate the push toward specialization in Medicine progressed in a confused and desultory manner. In response to this haphazard approach as well as mounting external pressures and internal power struggles, specialties began to form their own organizations to determine who was a bona fide specialist. These self-governed and self-regulated groups became known as "boards," and they went about evaluating candidates with written and oral examinations as well as face-to-face interviews.

The first board was created in 1917 for ophthalmology and was followed by boards for otolaryngology (1924), obstetrics and gynecology (1930), pediatrics (1933), psychiatry and neurology (1934), radiology (1934), and pathology (1936). Certification by a board indicated a practitioner's level of expertise; thus the limits of specialization set by the board delineated the clinical boundaries of the specialty. For example, in 1936, practitioners of medicine organized a board to cover the whole of internal medicine. In doing so, the specialty exerted firm control over its budding subspecialties, including cardiology, endocrinology, gastroenterology, hematology, and infectious disease. Surgery took a more difficult and divisive path. Before surgeons were able to establish a board for the overall practice of surgery, surgical subspecialists had organized separate boards in otolaryngology, colon and rectal (1935), ophthalmology, orthopedics (1935), and urology (1935). The presence of these surgical subspecialty boards left an open and troubling question: What was to become of the general surgeon?

In the mid-1930s, a faction of younger general surgeons, led by Evarts Graham (1883-1957), decided to set themselves apart from what they considered the less than exacting admission standards of the American College of Surgeons. Graham was professor of surgery at Washington University in St. Louis and the famed discoverer of cholecystography. He demonstrated the link between cigarettes and cancer and performed the first successful one-stage pneumonectomy (as fate would have it, the chain-smoking Graham died of lung cancer). Graham would go on to dominate the politics of American surgery from the 1930s through the 1950s. For now, Graham and his supporters told the leaders of the American College of Surgeons about their plans to organize a certifying board for general surgeons. Representatives of the American College of Surgeons reluctantly agreed to cooperate, and the American Board of Surgery was organized in 1937.

Despite optimism that the American Board of Surgery could formulate a certification procedure for the whole of surgery, its actual effect was limited. Graham attempted to restrain the surgical subspecialties by brokering a relationship between the American Board of Surgery and the subspecialty boards. It was a futile effort. The surgical subspecialty boards pointed to the educational and financial rewards that their own certification represented as reason enough to remain apart from general surgeons. The American Board of Surgery never gained control of the surgical subspecialties and was unable to establish a governing position within the whole of surgery. To this day, little economic or political commonality exists between general surgery and the various subspecialties. The consequence is a surgical lobby that functions in a divided and inefficient manner.

Although the beginning of board certification was a muddled and contentious process, the establishment of the various boards did bring about important organizational changes to Medicine in the United States. The professional status and clinical authority that board certification afforded helped distinguish branches and sub-branches of Medicine and facilitated the rapid growth of specialization. By 1950, almost 40% of physicians in the United States identified themselves as full-time specialists, and of this group, greater than 50% were board certified. It was not long before hospitals began to require board certification as a qualification for staff membership and admitting privileges.

THE MODERN ERA

The 3 decades of economic expansion after World War II had a dramatic impact on the scale of surgery, particularly in the United States. Seemingly overnight, Medicine became big business with health care rapidly transformed into society's largest growth industry. Spacious hospital complexes were built that epitomized not only the scientific advancement of the healing arts but also demonstrated the strength of America's postwar boom. Society gave surgical science unprecedented recognition as a prized national asset, noted by the vast expansion of the profession and the extensive distribution of surgeons throughout the United States. Large

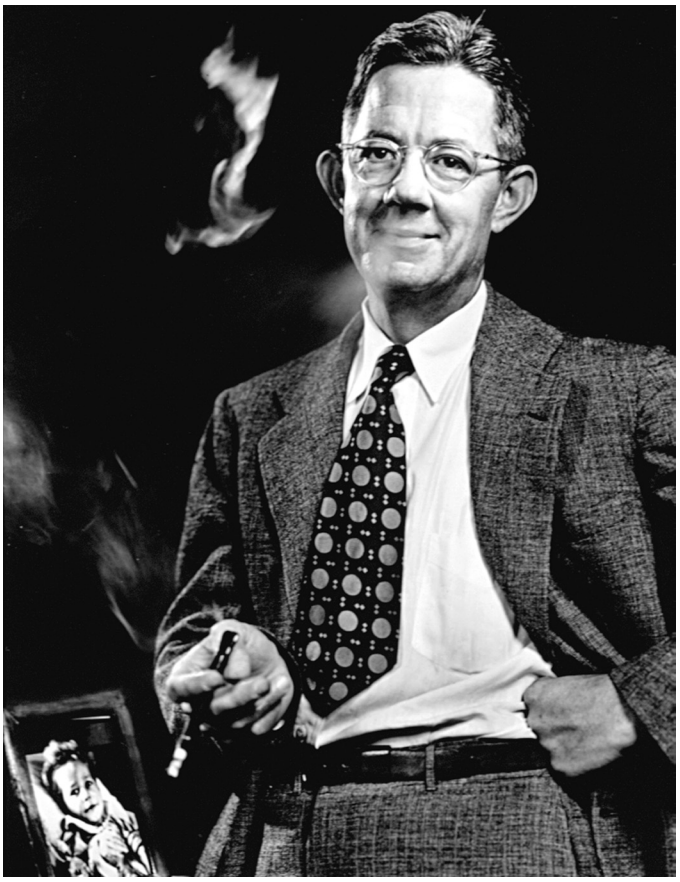


FIGURE 1-15 Alfred Blalock (1899-1964).

urban and community hospitals established surgical education and training programs and found it relatively easy to attract residents. Not only would surgeons command the highest salaries, but also Americans were enamored with the drama of the operating room. Television series, movies, novels, and the more than occasional live performance of a heart operation on television beckoned the lay individual.

It was an exciting time for American surgeons, with important advances made in the operating room and the basic science laboratory. This progress followed several celebrated general surgical firsts from the 1930s and 1940s, including work on surgical shock by Alfred Blalock (1899-1964) (Fig. 1-15), the introduction of pancreaticoduodenectomy for cancer of the pancreas by Allen Oldfather Whipple (1881-1963), and decompression of mechanical bowel obstruction by a suction apparatus by Owen Wangensteen. Among the difficulties in identifying the contributions to surgery after World War II is a surfeit of famous names—so much so that it becomes a difficult and invidious task to attempt any rational selection of representative personalities along with their significant writings. This dilemma was remedied in the early 1970s, when the American College of Surgeons and the American Surgical Association jointly sponsored SOSSUS (Study on Surgical Services for the United States). It was a unique and vast undertaking by the surgical profession to examine itself and its role in the future of health care in the United States. Within the study's three-volume report (1975) is an account from the surgical research subcommittee that named the most important surgical advances in the 1945-1970 era.

In this effort, a group of American surgeons, from all specialties and academic and private practice, attempted to appraise the relative importance of advances in their area of expertise. General surgeons considered kidney transplantation, the replacement of arteries by grafts, intravenous hyperalimentation, hemodialysis, vagotomy and antrectomy for peptic ulcer disease, closed chest resuscitation for cardiac arrest, the effect of hormones on cancer, and topical chemotherapy of burns to be of first-order importance. Of second-order importance were chemotherapy for cancer, identification and treatment of Zollinger-Ellison syndrome, the technique of portacaval shunt, research into the metabolic response to trauma, and endocrine surgery. Colectomy for ulcerative colitis, endarterectomy, the Fogarty balloon catheter, continuous suction drainage of wounds, and development of indwelling intravenous catheters were of third-order importance.

Among the other surgical specialties, research contributions deemed of first-order importance were as follows: Pediatric surgeons chose combined therapy for Wilms tumor; neurosurgeons chose shunts for hydrocephalus, stereotactic surgery and microneurosurgery, and the use of corticosteroids and osmotic diuretics for cerebral edema; orthopedists chose total hip replacement; urologists chose ileal conduits and the use of hormones to treat prostate cancer; otorhinolaryngologists selected surgery for conductive deafness; ophthalmologists selected photocoagulation and retinal surgery; and anesthesiologists selected the development of nonflammable anesthetics, skeletal muscle relaxants, and the use of arterial blood gas and pH measurements.

Additional innovations of second-order and third-order value consisted of the following: Pediatric surgeons chose understanding the pathogenesis and treatment of Hirschsprung's disease, the development of abdominal wall prostheses for omphalocele and gastroschisis, and surgery for imperforate anus; plastic surgeons chose silicone and Silastic implants, surgery of cleft lip and palate, and surgery of craniofacial anomalies; neurosurgeons chose percutaneous cordotomy and dorsal column stimulation for treatment of chronic pain and surgery for aneurysms of the brain; orthopedic surgeons chose Harrington rod instrumentation, compression plating, pelvic osteotomy for congenital dislocation of the hip, and synovectomy for rheumatoid arthritis; urologists selected the treatment of vesicoureteral reflux, diagnosis and treatment of renovascular hypertension, and surgery for urinary incontinence; otorhinolaryngologists selected translabyrinthine removal of acoustic neuroma, conservation surgery for laryngeal cancer, nasal septoplasty, and myringotomy and ventilation tube for serous otitis media; ophthalmologists selected fluorescein fundus angiography, intraocular microsurgery, binocular indirect ophthalmoscopy, cryoextraction of lens, corneal transplantation, and the development of contact lenses; and anesthesiologists chose progress in obstetric anesthesia and an understanding of the metabolism of volatile anesthetics.

All these advances were important to the rise of surgery, but the clinical developments that most captivated the public imagination and showcased the brilliance of post–World War II surgery were the growth of cardiac surgery and organ transplantation. Together, these two fields stand as signposts along the new surgical highway. Fascination with the heart goes far beyond that of clinical medicine. From the historical perspective of art, customs, literature, philosophy, religion, and science, the heart has represented the seat of the soul and the wellspring of life itself. Such reverence also meant that this noble organ was long considered a surgical untouchable.

Although suturing of a stab wound to the pericardium in 1893 by Daniel Hale Williams (1856-1931) and successful treatment of an injury that penetrated a cardiac chamber in 1902 by Luther

Hill (1862-1946) were significant triumphs, the development of safe cardiothoracic surgery that could be counted on as something other than an occasional event did not occur until the 1940s. During World War II, Dwight Harken (1910-1993) gained extensive battlefield experience in removing bullets and shrapnel in or near the heart and great vessels. Building on his wartime experience, Harken and other pioneering surgeons, including Charles Bailey (1910-1993), expanded intracardiac surgery by developing operations for the relief of mitral valve stenosis. In 1951, Charles Hufnagel (1916-1989), working at Georgetown University Medical Center, designed and inserted the first workable prosthetic heart valve in a man. The following year, Donald Murray (1894-1976) completed the first successful aortic valve homograft.

At approximately the same time, Alfred Blalock, professor of surgery at Johns Hopkins, working with Helen Taussig (1898-1986), a pediatrician, and Vivien Thomas (1910-1985), director of the hospital's surgical research laboratories, developed an operation for the relief of congenital defects of the pulmonary artery. The Blalock-Taussig-Thomas subclavian artery–pulmonary artery shunt for increasing blood flow to the lungs of a "blue baby" proved to be an important event in the rise of modern surgery. Not only was it a pioneering technical accomplishment, but it also managed to give many very ill children a relatively normal existence. The salutary effect of such a surgical feat, particularly its public relations value, on the growth of American surgery cannot be overstated.

Despite mounting successes, surgeons who operated on the heart had to contend not only with the quagmire of blood flowing through the area of dissection but also with the unrelenting to-and-fro motion of a beating heart. Technically complex cardiac repair procedures could not be developed further until these problems were solved. John H. Gibbon, Jr. (1903-1973) (Fig. 1-16), addressed this problem by devising a machine that would take on the work of the heart and lungs while the patient was under anesthesia, in essence pumping oxygen-rich blood through the circulatory system while bypassing the heart so that the organ could be more easily operated on. The first successful open heart operation in 1953, conducted with the use of a heart-lung machine, was a momentous surgical contribution.

The surgical treatment of coronary artery disease gained momentum during the 1960s, and by 1980, more cardiac operations were completed annually for coronary artery insufficiency than for all other types of cardiac disease. Although the performance of a coronary artery bypass procedure at the Cleveland Clinic in 1967 by René Favaloro (1923-2000) is commonly regarded as the first successful surgical approach to coronary artery disease, Michael DeBakey (1908-2008) (Fig. 1-17) had completed a similar procedure 3 years earlier but did not report the case until 1973. DeBakey is probably the best-known American surgeon of the modern era. He was a renowned cardiac and vascular surgeon, clinical researcher, medical educator, and international medical statesman as well as the long-time Chancellor of Baylor College of Medicine. He pioneered the use of Dacron grafts to replace or repair blood vessels, invented the roller pump, developed ventricular assist devices, and created an early version of what became the Mobile Army Surgical Hospital (MASH) unit. DeBakey was an influential advisor to the federal government about health care policy and served as chairman of the President's Commission on Heart Disease, Cancer, and Stroke during the Lyndon Johnson administration.

As reported in SOSSUS, when cardiothoracic surgeons were queried about first-order advances in their specialty for the 1945-1970 time period, they selected cardiopulmonary bypass, open and closed correction of congenital cardiovascular disease, the development of prosthetic heart valves, and the use of cardiac pacemakers. Of second-order significance was coronary bypass for coronary artery disease.

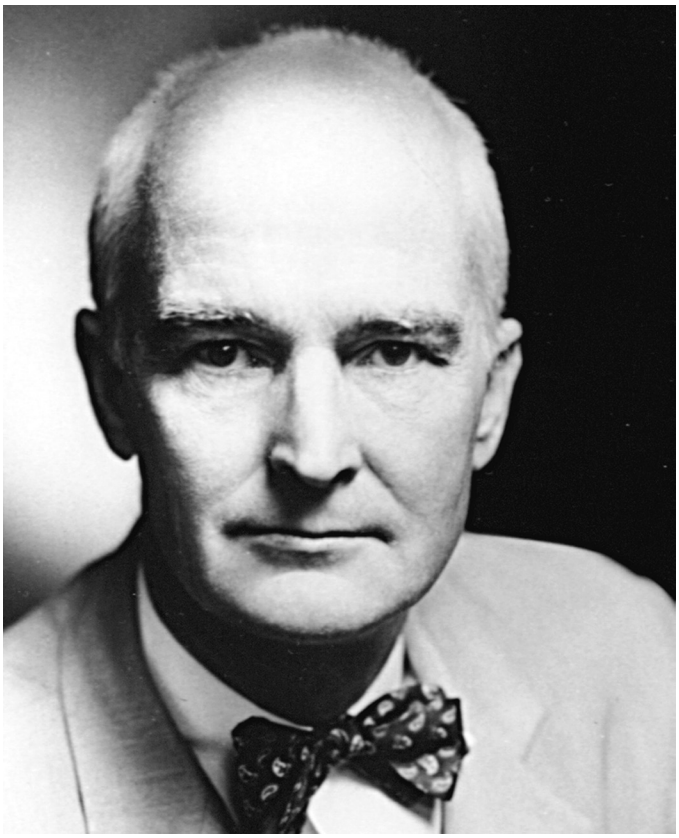


FIGURE 1-16 John H. Gibbon, Jr. (1903-1973).

FIGURE 1-17 Michael DeBakey (1908-2008).

What about the replacement of damaged or diseased organs? Even in the mid-20th century, the thought of successfully transplanting worn-out or unhealthy body parts verged on scientific fantasy. At the beginning of the 20th century, Alexis Carrel had developed revolutionary new suturing techniques to anastomose the smallest blood vessels. Using his surgical élan on experimental animals, Carrel began to transplant kidneys, hearts, and spleens.

His research was a technical success, but some unknown biologic process always led to rejection of the transplanted organ and death of the animal. By the middle of the 20th century, medical researchers began to clarify the presence of underlying defensive immune reactions and the necessity of creating immunosuppression as a method to allow the host to accept the foreign transplant. In the 1950s, using high-powered immunosuppressant drugs and other modern modalities, David Hume (1917-1973), John Merrill (1917-1986), Francis Moore, and Joseph Murray blazed the way with kidney transplants. In 1963, the first human liver transplant occurred; 4 years later, Christiaan Barnard (1922-2001) successfully completed a human heart transplant.

DIVERSITY

The evolution of surgery has been influenced by ethnic, gender, racial, and religious bias. Every segment of society is affected by such discrimination, particularly African Americans, women, and certain immigrant groups, who were victims of injustices that forced them into struggles to attain competency in surgery. In the 1930s, Arthur Dean Bevan (1861-1943), professor of surgery at Rush Medical College and an important voice in American surgery, urged that restrictive measures be taken against individuals with Jewish-sounding surnames to decrease their presence in Medicine. It would be historically wrong to deny the long-whispered belief held by the Jewish medical community that anti-Semitism was particularly rife in general surgery before the 1950s compared with the other surgical specialties.

In 1868, a department of surgery was established at Howard University. However, the first three chairmen all were white Anglo-Saxon Protestants. Not until 1928, when Austin Curtis (1868-1939) was appointed professor of surgery, did the department have its first African American head. Similar to all black physicians of his era, Curtis was forced to train at a so-called Negro hospital, Provident Hospital in Chicago, where he came under the tutelage of Daniel Hale Williams, the most influential and highly regarded of that era's African American surgeons.

With little likelihood of obtaining membership in the AMA or its related societies, African American physicians joined together in 1895 to form the National Medical Association. Black surgeons identified an even more specific need when the Surgical Section of the National Medical Association was created in 1906. From its start, the Surgical Section held "hands-on" surgical clinics, which represented the earliest example of organized, so-called "show me" surgical education in the United States. When Williams was named a Fellow of the American College of Surgeons in 1913, the news spread rapidly throughout the African American surgical community. Still, applications of African American surgeons for the American College of Surgeons were often acted on slowly, which suggests that denials based on race were clandestinely conducted throughout much of the United States.

In the mid-1940s, Charles Drew, chairman of the Department of Surgery at Howard University School of Medicine, acknowledged that he refused to accept membership in the American College of Surgeons because this supposedly representative surgical society had, in his opinion, not yet begun to accept routinely capable and well-qualified African American surgeons. Strides toward more racial equality within the profession have been taken since that time, as noted in the career of Claude H. Organ, Jr. (1926-2005) (Fig. 1-18), a distinguished editor, educator, and historian. Among his books, the two-volume *A Century of Black Surgeons: The U.S.A. Experience* and the authoritative *Noteworthy Publications by African-American Surgeons* underscored the numerous contributions made by African American surgeons to the U.S. health care system. In addition, as the long-standing editor-in-chief of the *Archives of Surgery* as well as serving as president of the American College of Surgeons and chairman of the American Board of Surgery, Organ wielded enormous influence over the direction of American surgery.

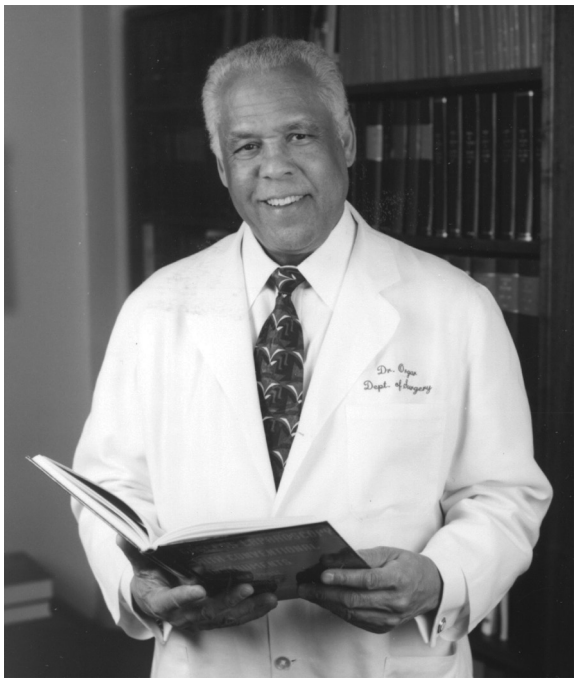


FIGURE 1-18 Claude H. Organ, Jr. (1926-2005).

One of the many overlooked areas of surgical history concerns the involvement of women. Until more recent times, options for women to obtain advanced surgical training were severely restricted. The major reason was that through the mid-20th century, only a handful of women had performed enough operative surgery to become skilled mentors. Without role models and with limited access to hospital positions, the ability of the few practicing female physicians to specialize in surgery seemed an impossibility. Consequently, women surgeons were forced to use different career strategies than men and to have more divergent goals of personal success to achieve professional satisfaction.

Through it all and with the aid of several enlightened male surgeons, most notably William Williams Keen of Philadelphia and William Byford (1817-1890) of Chicago, a small cadre of female surgeons did exist in turn-of-the-century America, including Mary Dixon Jones (1828-1908), Emmeline Horton Cleveland (1829-1878), Mary Harris Thompson (1829-1895), Anna Elizabeth Broomall (1847-1931), and Marie Mergler (1851-1901). The move toward full gender equality is seen in the role that Olga Jonasson (1934-2006) (Fig. 1-19), a pioneer in clinical transplantation, played in encouraging women to enter the modern, male-dominated world of surgery. In 1987, when she was named chair of the Department of Surgery at Ohio State University College of Medicine, Jonasson became the first woman in the United States to head an academic surgery department at a coeducational medical school.

FIGURE 1-19 Olga Jonasson (1934-2006).

THE FUTURE

History is easiest to write and understand when the principal story has already finished. However, surgery continues to evolve. As a result, drawing neat and tidy conclusions about the future of the profession is a difficult task fraught with ill-conceived conclusions and incomplete answers. Nonetheless, several millennia of history provide plentiful insights on where surgery has been and where it might be going.

Throughout its rise, the practice of surgery has been largely defined by its tools and the manual aspects of the craft. The last decades of the 20th century and beginning years of the 21st century saw unprecedented progress in the development of new instrumentation and imaging techniques. Advancement will assuredly continue; if the study of surgical history offers any lesson, it is that progress can always be expected, at least relative to technology. There will be more sophisticated surgical operations with better results. Automation will robotize the surgeon's hand for certain procedures. Still, the surgical sciences will always retain their historical roots as fundamentally a manually based art and craft.

Despite the many advances, these refinements have not come without noticeable social, economic, and political costs. These dilemmas frequently overshadow clinical triumphs, and this suggests that going forward, the most difficult challenges of surgeons may not be in the clinical realm but, instead, in better understanding the sociologic forces that affect the practice of surgery. The most recent years can be seen as the beginnings of a schizophrenic existence for surgeons in that newly devised complex and lifesaving operations are met with innumerable accolades, whereas criticism of the economics of surgery portrays the surgeon as a financially driven selfish individual.

Although they are philosophically inconsistent, the very dramatic and theatrical features of surgery, which make surgeons heroes from one perspective and symbols of mendacity and greed from the opposite point of view, are the very reasons why society demands so much of surgeons. There is the precise and definitive nature of surgical intervention, the expectation of success that surrounds every operation, the short time frame in which outcomes are realized, the high income levels of most surgeons, and the insatiable inquisitiveness of lay individuals about every aspect of consensually cutting into another human's flesh. These phenomena, ever more sensitized in this age of mass media and instantaneous communication, make surgeons seem more accountable than their medical colleagues and, simultaneously, symbolic of the best and worst in Medicine. In ways that were previously unimaginable, this vast economic, political, and social transformation of surgery controls the fate of the individual surgeon to a much greater extent than surgeons as a collective force can manage through their own profession.

National political aims have become overwhelming factors in securing and shepherding the future growth of surgery. Modern surgery is an arena of tradeoffs, a balance between costs, organization, technical advances, and expectations. Patients will be forced to confront the reality that no matter how advanced surgery becomes, it cannot solve all the health-related problems in life. Society will need to come to terms with where the ethical lines should be drawn on everything from face transplants to robotized surgery to gene therapy for surgical diseases. The ultimate question remains: How can the advance of science, technology, and ethics be brought together in the gray area between private and public good?

Studying the fascinating history of our profession, with its many magnificent personalities and outstanding scientific achievements, may not help us predict the future of surgery. Recall Theodor Billroth's remark at the end of the 19th century, "A surgeon who tries to suture a heart wound deserves to lose the esteem of his colleagues." The surgical crystal ball is a cloudy one at best. However, to understand our past does shed some light on current and future clinical practices. Still, if history teaches us anything, it is that surgery will advance and grow inexorably. If surgeons in the future wish to be regarded as more than mere technicians, members of the profession need to appreciate the value of its past glories better. Study our history. Understand our past. Do not allow the rich heritage of surgery to be forgotten.

SELECTED REFERENCES

Earle AS: *Surgery in America: from the colonial era to the twentieth century*, New York, 1983, Praeger.

This is a fascinating compilation of journal articles by well-known surgeons that traces the development of the art and science of surgery in the United States.

Hurwitz A, Degenshein GA: *Milestones in modern surgery*, New York, 1958, Hoeber-Harper.

The numerous chapters contain biographical information and a reprinted or translated excerpt of each surgeon's most important surgical contribution.

Leonardo RA: *History of surgery*, New York, 1943, Froben.
Leonardo RA: *Lives of master surgeons*, New York, 1948, Froben.
Leonardo RA: *Lives of master surgeons, supplement 1*, New York, 1949, Froben.

These three texts together provide an in-depth description of the whole of surgery, from ancient times to the mid-20th century. Especially valuable are the countless biographies of famous and near-famous surgeons.

Meade RH: *A history of thoracic surgery*, Springfield, Ill, 1961, Charles C Thomas.
Meade RH: *An introduction to the history of general surgery*, Philadelphia, 1968, Saunders.

With extensive bibliographies, these two books are among the most ambitious of such systematic works.

Porter R: *The greatest benefit to mankind, a medical history of humanity*, New York, 1997, WW Norton.

Although more a history of the whole of medicine than of surgery, this text became an instantaneous classic and should be required reading for all physicians and surgeons.

Rutkow I: *The history of surgery in the United States, 1775–1900*, vol 1, San Francisco, 1988, Norman Publishing.
Rutkow I: *The history of surgery in the United States, 1775–1900*, vol 2, San Francisco, 1992, Norman Publishing.
Rutkow I: *Surgery, an illustrated history*, St. Louis, 1993, Mosby-Year Book.
Rutkow I: *American surgery, an illustrated history*, Philadelphia, 1998, Lippincott-Raven.
Rutkow I: *Seeking the cure: a history of medicine in America*, New York, 2010, Scribner.

Using biographical compilations, colored illustrations, and detailed narratives, these five books explore the evolution of surgery.

Thorwald J: *The century of the surgeon*, New York, 1956, Pantheon.
Thorwald J: *The triumph of surgery*, New York, 1960, Pantheon.

In dramatic fashion, in these two books, the author uses a fictional eyewitness narrator to create continuity in the story of surgery during its most important decades of growth, the late 19th and early 20th centuries.

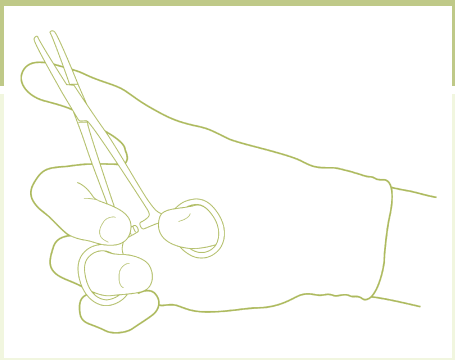
Wangensteen OH, Wangensteen SD: *The rise of surgery, from empiric craft to scientific discipline*, Minneapolis, 1978, University of Minnesota Press.

This is not a systematic history but an assessment of various operative techniques and technical innovations that contributed to or slowed the evolution of surgery.

Zimmerman LM, Veith I: *Great ideas in the history of surgery*, Baltimore, 1961, Williams & Wilkins.

Well-written biographical narratives accompany numerous readings and translations from the works of almost 50 renowned surgeons of varying eras.

2 CHAPTER



Ethics and Professionalism in Surgery

Cheryl E. Vaiani, Howard Brody

OUTLINE

THE IMPORTANCE OF ETHICS IN SURGERY

Although the ethical precepts of respect for persons, beneficence, nonmaleficence, and justice have been fundamental to the practice of medicine since ancient times, ethics has assumed an increasingly visible and codified position in health care over the past 50 years. The Joint Commission, the courts, presidential commissions, medical school and residency curriculum planners, professional organizations, the media, and the public all have grappled with determining the right course of action in health care matters. The explosion of medical technology and knowledge, changes in the organizational arrangement and financing of the health care system, and challenges to traditional precepts posed by the corporatization of medicine all have created new ethical questions.

The practice of medicine or surgery is, at its center, a moral enterprise. Although clinical proficiency and surgical skill are crucial, so are the moral dimensions of a surgeon's practice. According to Bosk,[1] a sociologist, the surgeon's actions and patient outcome are more closely linked in surgery than in medicine, and that linkage dramatically changes the relationship between the surgeon and the patient. Little,[2] a surgeon and humanist, suggested that there is a distinct moral domain within the surgeon-patient relationship. According to Little, "testing and negotiating the reality of the category of rescue, negotiating the inherent proximity of the relationship, revealing the nature of the ordeal, offering and providing support through its course, and being there for the other in the aftermath of the surgical encounter, are ideals on which to build a distinctively surgical ethics."[2] Because surgery is an extreme experience for the patient, surgeons have a unique opportunity to understand their patients' stories and provide support for them. The virtue and duty of engaged presence as described by Little extends beyond a warm, friendly personality and can be taught by precept and example. Although Little does not specifically identify trust as a component of presence, it seems inherent to the moral depth of the surgeon-patient relationship. During surgery, the patient is in a totally vulnerable position, and a high level of trust is demanded for the patient to place his or her life directly in the surgeon's hands. Such trust requires that the surgeon strive to act always in a trustworthy manner.

From the Hippocratic Oath to the 1847 American Medical Association statement of medical principles through the present, the traditional ethical precepts of the medical profession have included the primacy of patient welfare. The American College of Surgeons was founded in 1913 on the principles of high-quality care for the surgical patient and the ethical and competent practice of surgery. The preamble to its Statement on Principles states the following[3]:

> The American College of Surgeons has had a deep and effective concern for the improvement of patient care and for the ethical practice of medicine. The ethical practice of medicine establishes and ensures an environment in which all individuals are treated with respect and tolerance; discrimination or harassment on the basis of age, sexual preference, gender, race, disease, disability, or religion, are proscribed as being inconsistent with the ideals and principles of the American College of Surgeons.

The Code of Professional Conduct continues[4]:

> As Fellows of the American College of Surgeons, we treasure the trust that our patients have placed in us, because trust is integral to the practice of surgery. During the continuum of pre-, intra-, and postoperative care, we accept responsibilities to:
> - Serve as effective advocates of our patients' needs.
> - Disclose therapeutic options, including their risks and benefits.
> - Disclose and resolve any conflict of interest that might influence decisions regarding care.
> - Be sensitive and respectful of patients, understanding their vulnerability during the perioperative period.
> - Fully disclose adverse events and medical errors.
> - Acknowledge patients' psychological, social, cultural, and spiritual needs.
> - Encompass within our surgical care the special needs of terminally ill patients.