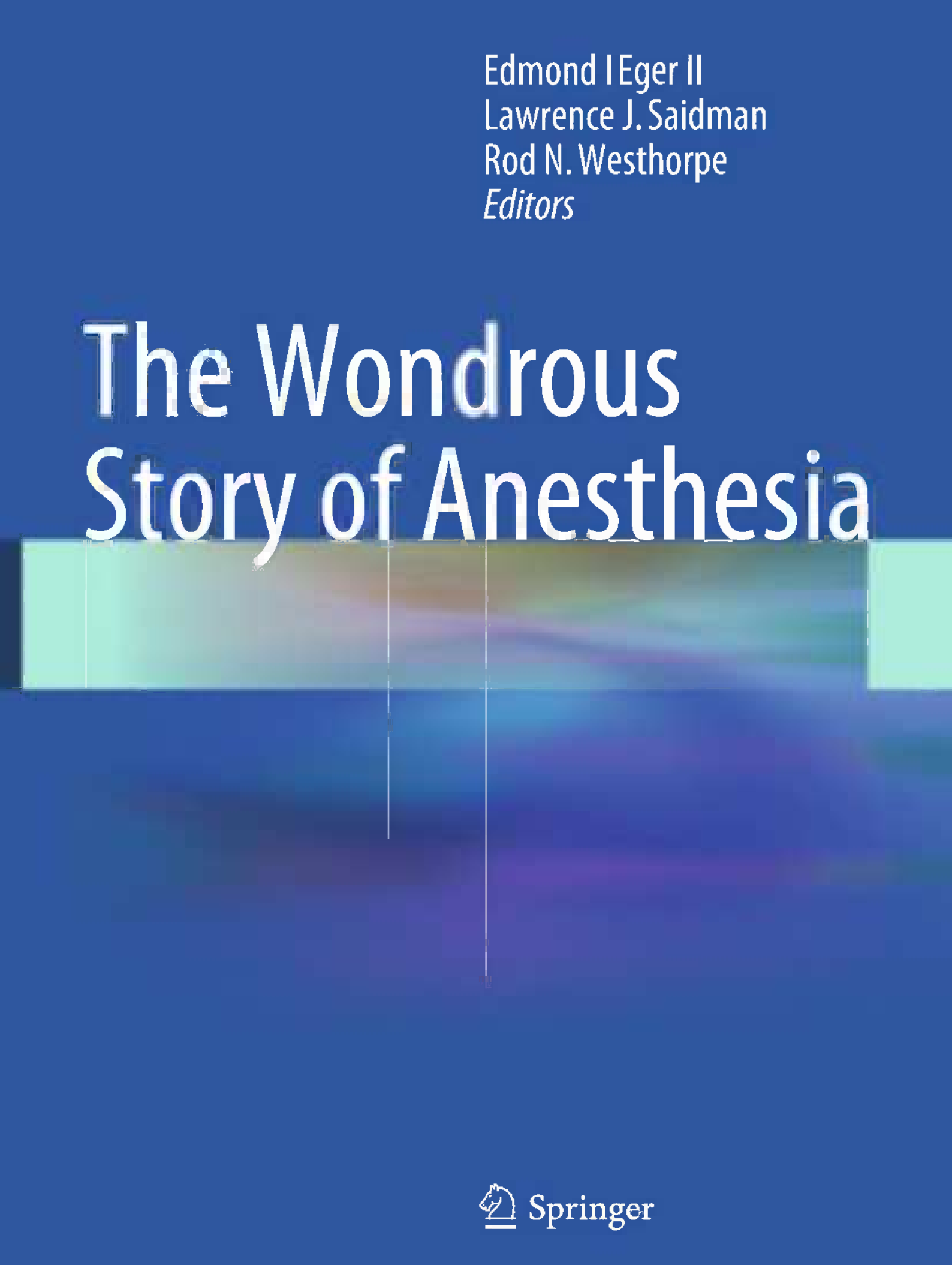
Edmond I Eger II
Lawrence J. Saidman
Rod N. Westhorpe
Editors

The Wondrous Story of Anesthesia



Springer

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To those responsible for the discovery and evolution of anesthesia.

Preface

This story describes events in three succeeding eras: first, events during the time preceding and immediately after the demonstration of anesthesia; then those in the subsequent 90 years of slow evolution of the specialty, ending in the 1950s; and finally those from the 1950s to the present, a period of explosive growth. Our lives span the last of these, the era in which modern anesthesia evolved from empiricism—"doing what worked"—to a practice relying on science and evidenced-based medicine. We sought to tell this story before too many grand participants died or were unable to tell their story. Many died in the past decade: Safar (2003); Marx (2004); Greene (2005)—including since we began this project in 2007—Haglund, Ibsen and Keats (2007); Gray (2008); Parsloe (2009); Smith and Terrell (2010); Gordh, Morris and Pierce (2011). We would have lost too many opportunities had we failed to act.

We enlisted 100 authors to construct 53 chapters (The Individual Stories) describing specific aspects of the evolution of anesthesia: people, countries, drugs, science, organizations, education, and more, each a thread in the tapestry of a larger story, each chapter written by anesthetists and others who lived this history. These 53 chapters make up the second part of our book. The first part wove stories from these chapters into chronologies described in 14 additional chapters (The Woven Stories) which provide a coherent picture of the development of anesthesia, a framework that facilitates an understanding of how events and people described in the second part of the book jointly shaped the development of the specialty.

Our contributors represent the Americas, Europe, the Middle and Far East, and Australia and New Zealand. They were chosen because of demonstrated expertise and/or actual participation in the development of a specific subject or of the specialty in a specific geographic area. Several chapter titles may seem idiosyncratic for a history book and were chosen because the subjects seemed to represent existing trends that were likely to influence the future.

A book of this breadth could not have been produced without the help supplied by our 100 contributors. Each endured multiple suggestions, changes, requests for no fewer than four revisions and a gentle nagging for more and more and more that in retrospect probably bordered on abuse. A few did not tolerate our intrusiveness and withdrew before completing their assignments. Fortunately, replacements were found and despite a shortened timeline for completion they met our deadlines. To all of these dear friends we offer our gratitude—we are in your debt!

The book is a story, not a recitation of pharmacology or physiology. It is not intended to educate the student in techniques or mechanisms. It describes the issues that shaped anesthesia, the incidents and humor, the anecdotes that put a human face to this wonderful specialty. We hope it shows the interactions between diverse forces that made this great specialty grow, and provides a sense of where those forces may take us in the future.

We three editors (Fig. 1) and many of our contributors hail from English speaking countries. While our respective forms of English are nearly identical they do differ slightly in spellings, e.g., an(a)esthesia, vapo(u)r, (o)esophagus, antagoni(s)ze, and many more. Rather than dictating the use of American English throughout, we elected to use the spelling common to the country of the chapter's author(s).

Redundancy in the descriptions of subjects, persons, and events is a frequent complaint lodged against multi-authored books, especially those like ours wherein the stories span centuries. Rather than purging the text of such repetitions, we allowed them to remain where and

Fig. 1 The three editors, from left to right: Edmond (Ted) Eger, Lawrence J. Saidman, and Rod N. Westhorpe

whenever they obviously belonged. The largest example, the discussion of Danish anesthesiologist Bjørn Ibsen's impact upon intensive care medicine, intensive care units, and associated issues appears in five chapters, each with its own focus.

Finally, a tribute to **The Power of Three** (Fig. 1). As might have been expected, in the 6 years over which we wrote and re-wrote this book, we disagreed regarding the how, who, when, where, why, and whether of many things. We settled each of these disputes (mostly) without rancor by taking a vote. For anyone anticipating a similar future exercise, we advise avoiding an even number of participants.

It has been a wonderful journey that has allowed us to re-live lives we loved.

San Francisco, CA, USA — Edmond I Eger II
Stanford, CA, USA — Lawrence J. Saidman
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Contents

Part I The Woven Story of Anesthesia: Eras, Exemplars, and Looking Forward

1 History to 1798 3
Edmond I Eger II, Lawrence J. Saidman and Rod N. Westhorpe

2 The Half Century Before Ether Day 11
Edmond I Eger II, Rod N. Westhorpe and Lawrence J. Saidman

3 1844–1846: The Discovery and Demonstration of Anesthesia 17
Edmond I Eger II, Lawrence J. Saidman and Rod N. Westhorpe

4 1846–1860: Following the Discovery of Anesthesia 27
Edmond I Eger II, Rod N. Westhorpe and Lawrence J. Saidman

5 1860–1910: The Specialty of Anesthesia Develops Slowly 37
Edmond I Eger II, Lawrence J. Saidman and Rod N. Westhorpe

6 1910–1950: Anesthesia Before, During, and After Two World Wars 51
Edmond I Eger II, Rod N. Westhorpe and Lawrence J. Saidman

7 History Reflected in the Evolving Approaches to Anesthesia for a Patient Undergoing Cholecystectomy 71
Lawrence J. Saidman, Rod N. Westhorpe and Edmond I Eger II

8 Major Anesthetic Themes in the 1950s 77
Edmond I Eger II, Lawrence J. Saidman and Rod N. Westhorpe

9 Major Anesthetic Themes in the 1960s 93
Lawrence J. Saidman, Rod N. Westhorpe and Edmond I Eger II

10 Major Anesthetic Themes in the 1970s 105
Rod N. Westhorpe, Lawrence J. Saidman and Edmond I Eger II

11 Major Anesthetic Themes in the 1980s 119
Rod N. Westhorpe, Lawrence J. Saidman and Edmond I Eger II

12 Significant Developments in the 1990s 131
Edmond I Eger II, Rod N. Westhorpe and Lawrence J. Saidman

13 Major Anesthesia-Related Events in the 2000s and Beyond 139
Lawrence J. Saidman, Rod N. Westhorpe and Edmond I Eger II

14 Predicting the Future 149
Lawrence J. Saidman, Rod N. Westhorpe and Edmond I Eger II

Part II Individual Stories

15 Surgery Before and After the Discovery of Anesthesia 163
William Silen and Elizabeth A. M. Frost

16 A History of Women in American Anesthesiology 185
Selma Harrison Calmes

17 Anesthesia, Anesthesiologists and Modern Medical Ethics 205
Stephen H. Jackson and Gail Van Norman

18 A History of Drug Addiction in Anesthesia 219
Christopher D. Kent and Karen B. Domino

19 The American Society of Anesthesiologists' Contributions to the Development of Anesthesiology 229
Peter L. McDermott

20 The Role of the International Anesthesia Research Society in the History of Anesthesia 243
Douglas Craig, Michael Cahalan, Davy C.H. Cheng, Colleen G. Koch and Robert N. Sladen

21 Establishment of Anesthesia Certification and the ABA 257
Francis P. Hughes, and Myer H. Rosenthal

22 The Evolution of Nurse Anesthesia in the United States 271
Bruce Evan Koch

23 A History of Veterinary Anesthesia 293
Eugene P. Steffey

24 The History of Anaesthesia in Australia and New Zealand 303
Rod N. Westhorpe

25 History of Canadian Anesthesia 321
Douglas Craig, Diane Biehl, Robert Byrick and John G. Wade

26 The History of Anesthesia in Mexico, the Caribbean Islands, and Central America 331
Estela Melman

27 A History of Anesthesia in China 345
Xiaomei Feng, Buwei Yu, Xuerong Yu, Yuguang Huang, Guolin Wang and Jin Liu

28 Aspects of the Development of Anesthesia in France 355
David Baker, Jean-Bernard Cazalaà and Marie-Thérèse Cousin

29 The Development of Anaesthesiology in German-Speaking Countries 371
Michael Goerig

30 The Evolution of Anaesthesia in the British Isles 391
Cedric Prys-Roberts

31 The History of Anesthesia in Japan 407
Kunio Suwa

32 A History of Nordic Anesthesia 417
Kjell Erik Stromskag, John G Brock-Utne, Jan Eklund and Martin H:son Holmdahl

33 A History of Anesthesia in South America 429
Adolfo Héctor Venturini

34 A History of Anaesthesia Journals 443
Jeanette Thirlwell

35 A History of the American Board of Anesthesiology Certifying Examinations 459
Stephen Slogoff

36 Development of the Certification Examination by the American Association of Nurse Anesthetists (1933–2012) 471
Susan S. Caulk and Karen Plaus

37 The Development of Education in Anesthesia in the United States 483
Manuel Pardo

38 Evolution of Education in Anesthesia in Europe 497
Thomas Pasch and Peter Simpson

39 A History of Research in Anesthesia 515
Edmond I Eger II

40 Pharmacokinetic and Pharmacodynamic Modeling in Anesthesia 525
Dennis M. Fisher and Steven L. Shafer

41 A Brief History of the Patient Safety Movement in Anaesthesia 541
William B. Runciman and Alan F. Merry

42 Where and How Does the Anesthetic Process Help or Hurt Patients Independent of Producing Anesthesia? 557
Harriet W. Hopf

43 The History of Outcomes Research in Anesthesia 569
Rod N. Westhorpe, Lawrence J. Saidman and Edmond I Eger II

44 A History of Pharmacogenomics Related to Anesthesiology 585
John C. Kraft, Jerry Kim, Debra A. Schwinn and Ruth Landau

45 The Unfolding Story of How General Anesthetics Act 597
Nicholas P. Franks

46 A History of Inhaled Anesthetics 609
Ron Jones

47 A History of Intravenous Anesthesia 629
Paul F. White

48 The History of Opioid Use in Anesthetic Delivery 641
Theodore H. Stanley

49 The Evolution of Premedication 661
Robert K. Stoelting

50 A History of Neuromuscular Block and Its Antagonism 671
James E. Caldwell

51 The Development of Local Anesthetics 693
Kenneth Drasner

52 Anesthesia Machines and Breathing Systems: An Evolutionary Success Story 703
Jerry A. Dorsch and Susan E. Dorsch

53 The Development of the Copper Kettle with Comments on Vaporizers that Preceded and Followed 715
Lucien E. Morris and Donald C. Morris

54 The Development of Techniques for Airway Management 723
Carin A. Hagberg, Amna A. Ghouse and Dawn G. Iannucci

55 History of Respiratory Gas Monitoring in Anesthesia 745
John W. Severinghaus

56 The Story of Artificial Ventilation 761
Keith Sykes

57 From Copenhagen to Critical Care 771
Keith Sykes

58 A History of Intensive Care Medicine 785
Jukka Takala

59 The Development of Ambulatory and Office-Based Anesthesia 799
Kathryn E. McGoldrick

60 The Anesthesiologist and Pain: A Historical Memoir 811
Daniel B. Carr and Michael J Cousins

61 A History of Cardiac Anesthesiology 829
Edward Lowenstein and J. G. Reves

62 A History of Pain Relief During Childbirth 847
William Camann

63 A History of Regional Anesthesia 859
Michael Mulroy

64 A History of Neuroanesthesia 871
Elizabeth A. M. Frost

65 Pediatric Anesthesia 887
George Gregory

66 Some Examples of Industry Contributions to the History of Anesthesia 905
Richard Leazer, David Needham, John (Iain) Glen and Paul Thomas

67 The History of the Anesthetist as a Perioperative Physician 923
Marlene R. Meyer and Jeanine P. Wiener-Kronish

Index 935

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Part I

The Woven Story of Anesthesia: Eras, Exemplars, and Looking Forward

History to 1798

1

Edmond I Eger II, Lawrence J. Saidman and Rod N. Westhorpe

Summary

Surgeons in ancient times undertook diverse operations, usually at great speed to diminish the duration of suffering. Skulls from 5,000 BCE show trephination, the removal of a piece of bone from the head. Egyptians in 3,600 BCE performed circumcisions and tracheotomies. In 1700 BCE, Babylonians excised tumors. Egyptians cauterized breast tumors and excised peripheral aneurysms. The Roman surgeon, Galen, in the second Century CE, treated cataracts to restore sight, and he cut out the uvula to cure chronic coughing. Surgeons in Europe might be physicians, monks or barbers who in the thirteenth and fourteenth centuries wrote books on surgery. They gained recognition by their study of the anatomy of cadavers. Thus, in 1543 Vesalius published "*On the Fabric of the Human Body*", demolishing centuries of errors, and opening the door to the performance of accurate surgery.

The horrors of pain, shock, and infection hindered surgeons. Operations brought infection, an added threat to life. Surgeons had surprising remedies, some desperately wrong (e.g., venesection), and some perhaps surprisingly wise (e.g., irrigating wounds with alcohol).

Before the advent of anesthesia, humans used diverse means to diminish pain, including pressure or ice to numb extremities. They administered herbal potions including mandragora, hemp-marijuana, opium, and alcohol. The Incas may have known of the topical effect of coca/cocaine, but they had no way to inject it other than spit coca-laced saliva into the wound. That might have some effect, but the amount of active cocaine was small and the effect probably too little to produce anesthesia.

Some potions contained hallucinogens, particularly scopolamine. Some prescriptions with wonderful names had unknown components: In 500 BCE, Hua Tuo gave "mafeisan" or "cannabis boil powder". In the Middle Ages, patients might suck liquid or breathe vapors from soporific sponges. And since the 1700s, we knew that we could produce immobility with a curare tipped dart, but we now know that would not eliminate pain.

Practitioners applied positive thinking and forms of suggestion, including modern magical rings, necklaces, and charms for the parturient. Greeks applied oils and warm compresses during labor, anticipating the warm compresses, massage and herbal teas used today. Were they placebos (which can have positive effects)? Mesmer's late eighteenth century creation of animal magnetism may have also relied on suggestion, perhaps a form of hypnosis that inconsistently assuaged surgical pain.

World Events Before 1798

The Jews credited 3761 BCE as the date of creation, but scientists suggest it was billions of years earlier. By 4000–3000 BCE, civilizations had arisen in China, Korea, Japan, Mesopotamia, and Egypt, aided by the development of agriculture, domestication of animals, invention of the wheel (including the potter's wheel), and writing. The Bronze Age appeared in 3000–2000 BCE, and the Egyptians constructed the pyramids. Parallel great kingdoms ruled Egypt and China, and an egalitarian civilization arose in the Indus Valley. In 2000–1000 BCE, Central Asian Indo-European invaders on horse-powered chariots overran Egypt and Babylonia. The Iron Age appeared in 1000–0 BCE, and Judaism, Zoroastrianism, Hinduism, Jainism and Buddhism developed. Greece conquered Persia, and the Romans conquered Greece and established the Roman Republic. In the first century CE, Rome dominated Europe, North Africa and the Near East, and the Han Dynasty ruled China. In the second century, Cai Lun invented paper, and Roman civilization peaked. The Prophet Muhammad began the Muslim conquests in 622 CE. In this century, India gave smallpox to Europe, and the world's population shrank to 200 million. In the eighth century, Arabian expansion continued,

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and Charlemagne came to power. Vikings repeatedly invaded Britain in the ninth century. The eleventh century saw the worst of Europe's Dark Ages (500–1500 CE), but great advances in science took place in China. Gutenberg invented mechanical movable type printing about 1439. The Spanish Inquisition began in 1492 the same year that Columbus landed in America. Copernicus proposed the sun as center of the universe in the 1540s. In the seventeenth century, Newton invented the calculus and his Laws of Motion. The eighteenth century saw French, American, and industrial revolutions, including invention of the steam engine.

Ancient Approaches to Pain Relief

We cringe, thinking of Galen, a prominent physician and surgeon in ancient Rome, [1] performing uvulectomy, cataract extractions, caesarean sections, and amputations in unanesthetized patients. We cringe, thinking of children forcibly restrained to allow surgery to proceed. Despite the absence of any clear path to pain-free surgery, surgeons in ancient times undertook diverse operations, usually at great speed to diminish the duration of suffering. How did these ancient surgeons deal with the issue of pain?

Ancient civilizations may have used pressure or ice to numb extremities. Magical herbs, including marijuana, might have been given. Perhaps the first known use of anesthesia came from China, where in 500 BCE, Hua Tuo combined herbs and wine into a concoction known as "mafeisan" or "cannabis boil powder".

In 40–90 CE, the Greek, Pedanius Dioscorides, used opium or mandragora to minimize pain during surgery. However, such therapies might be lethal or ineffective, or both. Opium could cause patients to stop breathing. Belladonna drugs in mandragora might lead to a fatal increase in temperature. Other surgeons experimented with opioids, alcohol, or a blow to the head—imperfect techniques that did not offer the control and reversibility required for anesthesia. Alcohol, for example, needed to be consumed in precisely the right quantity to cause unconsciousness, but not death. Persuading the underdosed inebriate to drink more might be impossible, and in the meantime, their irrational behavior and propensity to vomit made such a remedy ineffective.

Some remedies may have anticipated modern approaches. South American Indians may have chewed coca leaves and spat into the surgical field, thereby applying the first local anesthetic. However, the lack of cocaine alkaloids available in raw coca leaves may have limited its effectiveness [1].

[1] In the second century CE, Galen treated cataracts to restore sight and cut out the uvula to cure the chronic cough.

Surgery Without Anesthesia: A Painful Proposition

The Earliest Surgeries

A history of anesthesia is not complete without a discussion of the history of surgery. Anesthesia is a recent invention relative to surgery. Brutality attended the earliest surgeries. One early procedure appeared in all parts of the world except the Far East. Called "trephination," it involved making a hole through the patient's skull to expose the brain. Archeologists have unearthed skulls dating to 10,000 BCE, that show evidence of the practice. Some such skulls had healed, indicating that the holes resulted from a deliberate surgical act. The purpose of trephination remains a matter of speculation. Did it have religious implications? Did it release evil spirits?

Even in ancient times, humans performed complex surgical procedures. By 3,600 BCE, Egyptians performed tracheotomies, cutting a hole in a patient's windpipe to ease airflow. In 1,700–1,600 BCE, Egyptian surgeons operated on tumors and aneurysms. They used cautery to remove breast cancers and treat other ailments, literally burning away the offending body part.

So common were surgical procedures, that the 1,700 BCE Code of Hammurabi (Babylon) dictated the cost of surgeries, including incisions of tumors, giving discounts for operations on slaves. The Code dealt harshly with surgical failure: "if a physician make a large incision with the operating knife, and kill him, or open a tumor with the operating knife, and cut out the eye, his hands shall be cut off." We may assume that malpractice was rare.

Egyptian and Greek surgical practices may have anticipated modern therapies. *The Edwin Smith Papyrus*, an Ancient Egyptian medical text and the oldest known surgical treatise on trauma, described the healing of injuries in 3,000 BCE, and suggested the application of meat to wounds to decrease bleeding, possibly using tissue clotting factors to achieve hemostasis. The ancient Greeks treated wounds with wine, perhaps acting to sterilize the incisions.

Records indicate the types of care given to wounds during this period, and the diversity of surgical procedures, but few records indicated attempts to dull the pain of surgery. How did ancient humans endure having a quarter-sized hole bored into their skull, the extraction of tumors, and the destruction of maladies by burning? The agony is difficult to imagine.

As the new millennium approached, surgeries became more complex, and the center of progress shifted from Greece to Rome. The Romans contributed to the knowledge essential for conducting surgery. The ancient Roman physician, Celsus (25 BCE-CE 50), accurately described the body's response to trauma or infection, using terms characteristic of inflammation—redness, swelling, heat and pain. The great Roman surgeon, Galen (CE 129–199), performed

cataract extractions, perhaps by displacing the opaque lens into the vitreous humor with a needle. A surgeon to gladiators, he made major contributions to the knowledge of anatomy through his observations of normal and abnormal structure. He dissected pigs and apes because human dissection was forbidden. However, by relying on dissection of animals, some of his extrapolations to human anatomy initiated errors that continued for centuries, errors sustained because of Galen's fame.

Ancient Jews in the Middle East also conducted surgeries. The Talmud described the suturing of wounds, the reduction of dislocations, the amputation of limbs, and the performance of Caesarian sections. The Jews had quaint remedies including the application of onions to wounds, a therapy for preventing infection that has modern support [2].

Dealing with the Pain of Surgery in the Ninth Through Twelfth Centuries

Church edicts during the Middle Ages, particularly the Dark Ages, diminished the use of surgery, and in 1163, the church forbade monks from shedding blood—and thus from performing surgery. Enter the barbers, men taught surgery by the monks before the Church's prohibition. These barber-craftsmen continued performing surgeries. They repaired hernias, removed bladder stones and cataracts, among other procedures, thereby preserving a modicum of surgical craft.

Pain always accompanied surgery; what to do about the pain? In the Middle Ages, patients might suck liquid or breathe vapors from sponges which offered mandrake, henbane or other hallucinogens such as hyoscine and scopolamine [3]. It sounds wonderful, a sponge to cause sleep, to shield its beneficiaries from the cruelty of the knife.

> "The most popular method of inducing narcosis was the so-called soporific sponge, *spongia somnifera*. Historians have found descriptions of it in manuscripts dating to the ninth century. Nicholas of Salerno described its ingredients in the twelfth century as opium, hyoscyamine, mulberry juice, lettuce seed, hemlock, mandrake and ivy. A fresh sea-sponge was to be soaked in the mixture and allowed to dry 'in the sun during the dog-days until all the liquid is consumed.' When required for use, the concoction was re-constituted by dipping the sponge in water. Because the medieval manuscripts recommended applying the sponge to the subject's nostrils, it has been thought that this was meant to be a form of inhalation anesthesia, but there is good evidence that the potion was usually administered as a drink [4]."

Medieval physicians even thought of an antidote: "Reversal of the narcotizing effect was to be attained with the juice of fennel-root or with vinegar [4]." But the soporific sponge probably could not produce anesthesia. Patients given scopolamine may not remember the agony of surgery, but they would move in response to the inflicted pain, and they might move vigorously [5].

Thirteenth–Fourteenth Centuries: Ether is Synthesized and Surgery Grows

In 1275, Spaniard Raymond Lully (Fig. 1.1) created a compound that, centuries later, would become the world's most important anesthetic. He combined sulfuric acid with wine to produce ethyl ether, which he called sweet oil of vitriol. But Lully did nothing further with his discovery, and patients everywhere would have to wait nearly 600 years for ether to be used to produce anesthesia.

Italian and French surgery resumed, growing as the Middle Ages ended. Published in Salerno, the earliest book on operations, the Bamberg Surgery, elevated the prestige of Italian surgery. Italian and French barber-surgeon guilds competed with each other and with so-called "masters of surgery", for royal recognition and support. Italian master surgeon, Lanfranc of Milan, irrigated wounds with wine (as had Greek physicians 1,500 years earlier) before closure of the wounds. In 1,290, Lanfranc left for France, thereby transferring considerable surgical authority from Italy to France. His 1296 book, *Practice and Art of All of Surgery*, further inspired French surgery.

French master surgeon Guy de Chauliac's 1368 book, *Inventory of the Complete Works of Surgery,* supplemented Lanfranc's work. Both Lanfranc's and de Chauliac's books appeared in Latin, and thus were inaccessible to most barber-surgeons until translated into French and other European languages. This contributed to the stiff competition between the master surgeons (who were likely to speak Latin) and the barber-surgeon guilds. The books guided surgery in France, and to some extent in England, for two centuries. They advised treatment of tumors, sores, and fractures, and prescribed antidotes and drugs. England however, remained a backwater controlled primarily by barber-surgeons, who competed with the less numerous military surgeons.

Fifteenth and Sixteenth Centuries

The 1425 translation of Guy de Chauliac's book from Latin into French and English, aided the barber-surgeons (known as the "surgeons of the short gowns") in their mounting competition with Latin-educated university surgeons (the "long gown" academic surgeons). Barber-surgeons grew more numerous than their long-gown counterparts, in part because the barber surgeon was more accessible. Although the barber-surgeons lacked social status or academic rank, the public found them to be more approachable, and eventually recognized that they also possessed superior skills that decreased complications and mortality.

Two self-educated Frenchmen, Pierre Franco and Ambroise Paré, advanced surgery in France and the reputation of such surgery in the world. They learned to perform surgery

Fig. 1.1 In 1275, Raymond Lully (pictured with words coming from his mouth) synthesized diethyl ether ("ether") by mixing wine and sulphuric acid, calling it sweet oil of vitriol, but he made nothing of it

from itinerant lithotomists and herniotomists (Franco), and barber-surgeons (Paré). Franco is thought to have fought charlatans, and Paré helped bridge the divide between the barber-surgeons and academic surgeons.

The Renaissance generated a new era of discovery in surgery. The Renaissance diminished the power of the Church and thereby limited its power to prevent human dissection. As a consequence, surgeons gained important new insights into anatomy that materially advanced surgery. In 1543, 29 year-old Andreas Vesalius published his classic book *On the Fabric of the Human Body*, demolishing centuries of errors based on Galen's dissections of animals, or ignorant imaginings [6, 7].

A half-century later, in 1597, Gaspare Tagliacozzi published *The Surgery of Defects by Implantations*, a treatise on the management of mutilating injuries–plastic surgery in 1597. Tagliacozzi precisely instructed surgeons on the reconstruction of noses and ears. The uncomplaining immobilized patient waited for two or three weeks for the skin graft from the arm to gain circulation from the nose [6, 7]. Plastic surgery without a drop of anesthesia.

It was not for lack of an anesthetic. It was not for lack of an observation that the anesthetic might block pain. As Lully had done three centuries earlier, in 1540, 25 year-old Valerius Cordus (Fig. 1.2a) once again produced ether (sweet oil of vitriol) by adding sulfuric acid to wine [8, 9]. About the same time, Theophrastus Bombastus von Hohenheim (Fig. 1.2b), better known as Paracelsus [10] noted that ether "has associated with it such a sweetness that it is taken even by chickens, and they fall asleep from it for a while but awaken later without harm." Paracelsus continued, "On this sulphur no other judgment should be passed than that in diseases which need to be treated with anodynes (pain killers) it quiets all suffering without any harm, and relieves all pain, and quenches all fevers, and prevents complications in all illnesses [8]."

Why did no one notice? A potent painkiller, ether would eventually be widely used as an anesthetic, but Paracelsus died in 1541 without demonstrating this possibility. Had anyone tumbled to the possibilities inherent in Paracelsus' observation that ether put chickens to a reversible sleep, one which relieves all pain, anesthesia might have been discovered three centuries sooner.

Perhaps Italian scholar, polymath and playwright, John Baptista Porta, had discovered the anesthetic potential of ether. In his 1597 work on "*Natural Magic*," Porta noted:

> At last shall be related a wonderful method by which any sleeping person may inhale a soporific medicine. From what we have said, any one will easily know that he is liable to suffer severely after sleep caused by medicine, and to have his suspicions aroused [11]."
>
> "But the quintessence is extracted from a number of the above named medicines by somniferous (sleep-inducing) menstrual. This is put into leaden vessels perfectly closed, lest the least aura should escape, for the medicine would vanish away. When it is used, the cover being removed, it is applied to the nostrils of the sleeping person, he draws in the most subtile (sic) power of the vapour by smellings, and so blocks up the fortress of the senses that he is plunged into the most profound, sleep, and cannot be roused without the greatest effort. After the sleep, no heaviness of the head remains nor any suspicion of trick or fraud. These things are plain to the skilful physician, but unintelligible to the wicked [11]."

Although he does not describe what chemicals he uses, Porta (who sometimes was called a "professor of secrets") could have been describing ether. Much later, John Snow (author of *On Chloroform and other Anaesthetics: Their Action and Administration*) reflects on Porta's 1597 book and makes his own astute observations concerning Porta's description. Snow states,

> "The author [Porta] does not make known what the 'somniferous menstrual' were, with which the 'quinta essentia' were

Fig. 1.2a Using the approach used by Lully nearly three centuries earlier, Valerius Cordus (I.2) synthesized ether in 1540. **1.2b** However, this time someone—Paracelsus (I.3)—made observations on pharmacological qualities of the new compound: "…it quiets all suffering without any harm, and relieves all pain…"

> extracted. As sulphuric ether had been described more than fifty years before he published his work, it is not improbable that this was the evanescent substance which required the vessel be carefully closed up, and that the profound sleep was simply caused by this, as the narcotic principles dissolved in it would remain in the bottle in the form of extracts…Porta does not say that operations were performed under the influence of the inhalation, or in fact, that it was applied to any useful purpose whatever [11]".

Why didn't Porta apply his observations to relieve the pain of surgery? Why didn't Paracelsus do the same? As Winston Churchill observed: "Men stumble over the truth from time to time, but most pick themselves up and hurry off as if nothing happened."

And what of possibilities other than ether might there been to diminish pain? Shakespeare reminds us of remedies such as the Mandrake root:

> "Not poppy, nor mandragora,
> Nor all the drowsy syrups of the world,
> Shall ever medicine thee to that sweet sleep
> Which thou ow'dst yesterday."
> Shakespeare: Othello III.iii

Just like the soporific sponge, the Mandrake root contains deliriant hallucinogenic tropane alkaloids, such as hyoscyamine and scopolamine [12]. Those who take sufficient hyoscyamine (an alkaloid precursor of scopolamine) may lapse into a coma, one that adds a risk of lethal increases in temperature because scopolamine can prevent sweating [13]. Enormous doses of scopolamine or its sister, atropine, have been used in the treatment of depression, so they are relatively safe as long as the ambient temperature does not require sweating to keep cool [14, 15]. As already noted, although such doses may eliminate the remembrance of surgery, they do not produce anesthesia. They do not produce a patient who is immobile in the face of noxious stimulation [5].

The Seventeenth Century

By the turn of the seventeenth century, surgical procedures became more complex (and thus more painful), and the practice of medicine more professional. The scientific revolution was in full swing, and experimentation began to replace speculation. William Harvey's 1628 book, *An Anatomical Exercise on the Motion of the Heart and Blood in Living Beings*, described his momentous discoveries concerning the anatomy and physiology of the circulation of blood, how blood moved from heart to artery to vein and back again [7]. And Hieronymous Fabricius ab Aquopendente, a teacher to Harvey, not only demonstrated venous valves but also used a technique for tracheotomies—puncturing the windpipe to allow passage of air—that is similar to the approach used today. Adding to Harvey's contribution, in 1661, Marcello Malpighi described the capillaries and their function.

In the 1500s–1600s, Colleges of Physicians arose in England, Scotland and Ireland, acquiring the Royal prefix by the 1600s. This brought prestige to physicians (internists), but little to the surgeons. Surgeons continued to struggle for recognition in their field. French barber-surgeons eventually received the legal right to treat all wounds. As is the case today, the "private practice" barber-surgeons received higher fees

than their academic competition, the master surgeons. Even so, to make ends meet, in addition to doing surgery, barber-surgeons performed bloodletting and mundane wound care. They became more technically proficient than the academicians but did not contribute to advances in knowledge.

The seventeenth century saw the first demonstration of the possibility of intravenous anesthesia. In 1656, Christopher Wren (the architect for St. Paul's cathedral and a founder of the Royal Society) infused wine and ale from a syringe made of dog's bladder, through a goose quill needle into the vein of a dog [16, 17]. Wren wrote "I have injected wine and ale in a living dog into the mass of blood by a veine (sic), in good quantities, till I have made him extremely drunk, but soon after he pisseth it out." The dog survived the experiment. The dog, incidentally, was provided by Robert Boyle, author of Boyle's law.. Wren later gave opium intravenously via a quill to dogs, causing unconsciousness in some animals but killing others [17]. Wren's experiment was the first known injection to produce anesthesia.

The Eighteenth Century: The Verge of Discovery

The eighteenth century brought the professionalization of medicine to Europe and eventually, to the US. By the 1700s, academic surgeons gradually became recognized as professionals equal to physicians, largely because they demonstrated the importance and interdependence of pathological (diseased) anatomy and pathophysiology (diseased function). French surgical training increasingly included teaching an accepted body of knowledge in courses and schools. Two events moved French surgery closer to a profession. One was the 1731 establishment of the Royal Academy or College of Surgery. Second was a 1743 Royal Declaration, forbidding master surgeons to work as barbers. Laws promulgated after the initiation of the French Revolution in 1789, added to the rise of surgery in France. The Faculty of Medicine and the College of Surgery were abolished in 1792, replaced in 1794 by the School of Health that imposed identical educational requirements for those practicing medicine and surgery [6, 7].

In the last half of the eighteenth century, surgery in Great Britain also progressed rapidly. In 1745, the British Parliament separated surgeons from the barber guilds by enacting a bill that formed a Corporation of Surgeons. Led by Percival Pott and John Hunter, [6, 7] Britain displaced France as the most important European center for surgical education and training. Pott and Hunter's knowledge of anatomy advanced surgery as a scientific discipline. Hunter made important observations, describing, for example, the pathophysiology of surgical diseases, and supplying observations on malignant tumors and the growth of collateral circulation after arterial occlusion. This information was particularly important to treatment of aneurysms.[2] Pott connected the occupation of chimneysweeps with their development of scrotal cancer.

Medicine and surgery were stagnant in North America from 1600 to 1750, and self-educated "physicians" served most medical needs. As 1800 approached, Americans increasingly admired physicians, prompting progressive numbers of Americans to obtain training from the more advanced European system of medical education.

Eighteenth century internal medicine sped forward in diagnosis and treatment. The parallel development of eighteenth century pathological anatomy and experimental physiology strengthened the connection of internal medicine and surgery. Surgeons increasingly correlated disease with anatomical (pathological) changes. This reflected the view long held by physicians, that disease processes had physiologic consequences. Regardless of these developments, without anesthesia and antisepsis, surgery advanced slowly.

Several important discoveries were made during this period. One was by Englishman Joseph Priestly, who had committed himself to the ministry, but believed that understanding nature would further the aims of religion. Priestly's experiments resulted in the discovery of new gases or "airs", among them oxygen and nitrous oxide. He produced nitrous oxide by heating iron filings with nitric acid in 1772, publishing his studies three years later. However, like Paracelsus' oversight about the possibilities of ether two and a half centuries earlier, Priestly missed the significance of his discovery and little was then made of the new air.

Perhaps the most important discovery of the time originated from a 1735 expedition, led by French explorer Charles de la Condamine into South America's Amazon River region, where he observed the natives using blowpipes to propel poisonous arrows with lethal effects while hunting [18]. In 1769, while in South America, English physician Edwin Bancroft wrote of his observations of the natives concentrating the poisonous mix of bark and roots, noting that they avoided exposing wounds in their skin to the confection [19]. Bancroft brought samples of the poison, known as curare, back to England.

In 1811, English surgeon Benjamin Brodie, reported that although the poison caused breathing to cease in a donkey, the heart continued to beat, [20] and beating could be sustained if ventilation was supported [21]. In an 1814 demonstration, Brodie and Sewell, a veterinary surgeon, dramatically demonstrated the innocuousness of curare if ventilation

[2] Ironically, Hunter had angina pectoris, presciently noting that "my life is in the hands of any rascal who chooses to annoy and tease me." A fatal heart attack at age 65 followed an argument at St. Georges Hospital on 14 October 1793. Pott described the anatomy of congenital inguinal hernias in his "Treatise on Ruptures." He advocated emergent operations for incarcerated hernias. Most famous was his 1775 Chirurgical Observations, a 5-page essay correctly connecting scrotal cancer in chimney sweeps to their exposure to tars.

was supported. Sykes, a well-known surgeon described the experiment as follows [22]:

> A she-ass received the wourali poison in the shoulder, and died apparently in 10 min. An incision was made in its windpipe, and through it the lungs were regularly inflated for two hours with a pair of bellows. Suspended animation returned. The ass held up her head and looked around; but the inflating being discontinued, she sunk once more in apparent death. The artificial breathing was immediately recommenced, and continued without intermission for two hours more. This saved the ass from final dissolution; she rose up, and walked about; she seemed neither in agitation nor in pain. The wound, through which the poison entered, was healed without difficulty…and by Midsummer (the ass) became fat and frisky…The kind hearted reader will rejoice on learning that Earl Percy, pitying her misfortunes, sent her down from London to Walton Hall, near Wakefield. There she goes by the name Wouralia. Wouralia shall be sheltered from the wintry storm; and when the summer comes she shall feed in the finest pasture. No burden shall be place on her and she shall end her days in peace."

To survive the paralytic effects of curare, Wouralia the donkey had a tracheotomy and ventilation with a bellows. Wouralia did just as Sykes described, and lived another 25 years in peace. The local paper supplied an obituary.

Prior to Brodie and Sewell's experiments, interest had already developed in approaches to secure the airway. As a result, their efforts built on the practice of earlier surgeons like Hooke, Kite, Herholdt and Rafn. In 1667, Robert Hooke performed an extraordinary and cruel sequel to Vesalius' 1550s experiment. Hooke showed that blowing air down the windpipe and out through multiple punctures in the lungs of an awake dog sustained life, even though the lungs were still. In 1788, Kite ventilated a drowning victim's lungs through a tube he placed blindly through the oropharynx and into the windpipe. Nearly a decade later, Herholdt and Rafn described blind digitally assisted tracheal intubation, to resuscitate drowning victims.

Some aspects of modern surgery and management of the airway arose early. Concentrating cohorts of war casualties or victims of epidemics in one place enhances their monitoring and care—in ancient or modern times—anticipating the development of hospitals. The Bible implies the use of mouth-to-mouth respiration (2 Kings, iv, 34), and midwives used it to revive the new-born. Slowly, science and medicine would bring together the airway and ventilatory necessities, the concentrating of patients to supply the intensive care that became part of modern anesthesia.

And What About Positive Thinking?

Other than Priestly's discovery of nitrous oxide, little else anticipated the approaching demonstration of anesthesia in 1846 besides the mind control that physicians and others long had practiced. Practitioners have seemingly forever applied positive thinking and various forms of suggestion, including modern magical rings, necklaces and charms for the parturient. Greeks applied oils and warm compresses during labor, anticipating the warm compresses, massage and herbal teas used today. Were these placebos (which can have positive effects)? In the latter part of the eighteenth century, Franz Mesmer created "theories of animal magnetism," perhaps a form of hypnosis. Mesmerism provided an inconsistently effective management of the pain of surgery. The scientific establishment noted the absence of any rationale for Mesmerism's effectiveness.

Reprise

By the nineteenth century, the surgeon had become a full member of the medical community, contributing to the knowledge of human anatomy and pathology, and to an elaboration of surgical procedures. The operations performed included amputations, cataract removal, cesarean sections, cosmetic surgery, removal of bladder stones, ligation of major arteries, excision of superficial tumors, excision of anal fistulas, and repair of hernias. The range staggers the imagination, more so, given the absence of anesthesia. Surgeons focused on acute processes, conditions requiring immediate care: simple fractures, dislocations, and abscesses. Infection compromised treatment and was a constant threat to life. But most of all, pain limited the number of surgeries that might be performed, and thus limited progress in surgery.

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