SEVENTH EDITION

Basics of Anesthesia

Manuel C. Pardo, Jr.
Ronald D. Miller

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Basics of ANESTHESIA

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FOREWORD

The first edition of *Basics of Anesthesia*, edited by Robert K. Stoelting and Ronald D. Miller, was my first textbook of anesthesia. As an anesthesia resident at the University of California, San Francisco (UCSF), I relied on *Basics of Anesthesia* to provide concise coverage of fundamental principles and developments in our field. Drs. Stoelting's and Miller's co-editorship of the book continued through the fifth edition. The sixth edition, published in 2011 by Dr. Miller and new co-editor, Manuel C. Pardo, Jr., featured a companion website, Expert Consult, that presented the complete text and illustrations in an online format. This seventh edition of *Basics of Anesthesia* represents the culmination of Dr. Miller's 33-year stewardship of the book. We should admire his determined leadership to publish a textbook that offers the anesthesia community an invaluable educational resource reflecting the ever-evolving practice of anesthesia. This book is symbolic of Dr. Miller's uncompromising desire for all anesthesia learners and providers to walk in his path, in "the Pursuit of Excellence," which was the title of his Rovenstine Lecture at the Annual Meeting of the American Society of Anesthesiology in 2008.

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PREFACE TO THE SEVENTH EDITION

The *Basics of Anesthesia* continues its tradition of providing updated and concise information for the entire community of anesthesia learners. In this seventh edition, editors Ronald D. Miller and Manuel C. Pardo, Jr., have added four new chapters and rigorously updated all content to reflect evolving developments in the specialty. The editors are pleased to welcome the contribution of more than 30 new authors, mostly from the United States, but also from Japan, Australia, Canada, South Korea, and the United Kingdom.

This edition marks the transition to a new lead editor, Manuel C. Pardo, Jr., Professor of Anesthesia and Perioperative Care and Director of the Anesthesia Residency Program at the University of California, San Francisco. Dr. Pardo has worked alongside retiring lead editor, Dr. Miller, to identify emerging trends and chronicle advances in anesthesia care. In this edition the editors have eliminated the History chapter and added four new chapters: Chapter 12, "Anesthetic Neurotoxicity"; Chapter 49, "Palliative Care"; Chapter 50, "Sleep Medicine and Anesthesia"; and Chapter 51, "New Models of Anesthesia Care: Perioperative Medicine, the Perioperative Surgical Home, and Population Health." The editors elected to provide more in-depth coverage to the prior edition's chapter on "Trauma, Bioterrorism, and Natural Disasters," which has been split into two chapters: Chapter 42, "Anesthesia for Trauma," and Chapter 43, "Human-Induced and Natural Disasters." Multiple chapters have been restructured to promote clarity and organization of the material. In addition, we have continued to make extensive use of color figures, illustrations, and tables to present concepts in a focused manner. Each chapter has "Questions of the Day," which are designed to promote reflection on the chapter content. Many questions focus on understanding relevant basic concepts as well as analyzing challenging clinical situations.

We are extremely thankful to the authors of the current and previous editions of *Basics of Anesthesia* for their commitment to the excellence of the book. The editors also gratefully acknowledge the expertise of editorial analyst Tula Gourdin, who managed the communication with the authors, editors, and publisher and ensured that no detail was overlooked throughout the entire publication process. We also wish to acknowledge our publisher, Elsevier, and the dedication of their staff, including executive content strategists William R. Schmitt and Dolores Meloni, senior content development specialist Ann Ruzycka Anderson, and senior project manager Sharon Corell.

Ronald D. Miller

Manuel C. Pardo, Jr.

Chapter

1 SCOPE OF ANESTHESIA PRACTICE

Ronald D. Miller and Manuel C. Pardo, Jr.

The specialty of anesthesiology has evolved dramatically since the first public demonstration of ether use in the 19th century. Originally, the emphasis was completely on providing surgical anesthesia. As surgical procedures became more diverse and complex, other associated skills were developed. For example, airway management, including endotracheal intubation, was required to provide controlled ventilation to patients who had respiratory depression and paralysis from neuromuscular blocking drugs. These practices required the development of a "recovery room," which was later termed a *postoperative* or *postanesthesia care unit* (PACU) (Chapter 39). The skills that anesthesiologists used in the recovery room evolved and progressed into intensive care units (ICUs) and the specialty of critical care medicine (Chapter 41). The development of regional anesthesia created opportunities for treatment of some chronic pain syndromes (Chapters 40 and 44). Anesthesiology also evolved into a recognized medical specialty (as affirmed by the American Medical Association and the American Board of Medical Specialties), providing continuous improvement in patient care based on the introduction of new drugs and techniques made possible in large part by research in the basic and clinical sciences.

DEFINITION OF ANESTHESIOLOGY AS A SPECIALTY

A more formal definition of the specialty of anesthesiology is provided by The American Board of Anesthesiology (ABA).[1] The ABA defines anesthesiology as a

discipline within the practice of medicine dealing with but not limited to:

1. Assessment of, consultation for, and preparation of patients for anesthesia.
2. Relief and prevention of pain during and following surgical, obstetric, therapeutic, and diagnostic procedures.
3. Monitoring and maintenance of normal physiology during the perioperative period.
4. Management of critically ill patients including those receiving their care in an intensive care unit.
5. Diagnosis and treatment of acute, chronic, and cancer-related pain.
6. Management of hospice and palliative care.
7. Clinical management and teaching of cardiac, pulmonary, and neurologic resuscitation.
8. Evaluation of respiratory function and application of respiratory therapy.
9. Conduct of clinical, translational, and basic science research.
10. Supervision, instruction, and evaluation of performance of both medical and allied health personnel involved in perioperative or periprocedural care, hospice and palliative care, critical care, and pain management.
11. Administrative involvement in health care facilities and organizations, and medical schools as appropriate to the ABA's mission.

As with other medical specialties, anesthesiology is represented by professional societies (American Society of Anesthesiologists, International Anesthesia Research Society), scientific journals (Anesthesiology, Anesthesia & Analgesia), a residency review committee with delegated authority from the Accreditation Council for Graduate Medical Education (ACGME) to establish and ensure compliance of anesthesia residency training programs with published standards, and a medical specialty board, the ABA, that establishes criteria for becoming a certified specialist in anesthesiology. The ABA, in conjunction with other specialty boards, has also developed criteria for maintenance of certification, which includes a program of continual self-assessment and lifelong learning, along with periodic assessment of professional standing, cognitive expertise in practice performance, and improvement.[1] This describes the American system. Other countries and societies have their systems to certify specialists in anesthesiology. Some countries work in a collective manner to educate and certify specialists in anesthesiology (e.g., European Society of Anesthesia).

EVOLUTION OF ANESTHESIA AS A MULTIDISCIPLINARY MEDICAL SPECIALTY

In the last 50 years, the medical specialty of anesthesiology has progressively extended its influence outside the operating rooms. Initially, the most important non–operating room patient care skills developed by anesthesia providers have been in pain management (Chapters 40 and 44) and adult critical care medicine (Chapter 41). Beginning in the 1980s, anesthesia residency training required rotation experiences in these areas. In 1985, the ABA began issuing subspecialty certificates in critical care medicine to candidates who had completed at least a year of specialty training, thus becoming the first recognized subspecialty of anesthesiology. Pain medicine became the second subspecialty to be formally recognized when the ABA began issuing certificates in 1991. By this time, residency programs required rotations in multiple specialty areas, and fellowship programs in many areas were being developed. This reflected the progressive complexity of health care as well as extensive specialization in all fields of medicine.

Pain Management

Pain management is required in the perioperative setting (Chapter 40) as well as for chronic pain conditions (Chapter 44). The management of perioperative pain has become more complex as the relationship between postoperative pain control and functional outcomes (e.g., mobility after joint replacement surgery) has become more tightly linked. In addition, the increasing use of neuraxial and regional anesthesia techniques (Chapters 17 and 18) for postoperative pain management has led to increasingly specialized acute pain management services usually managed by anesthesiology.

An outpatient-based pain management center typically takes care of patients with chronic pain on an outpatient basis with occasional consultations in the hospital itself (e.g., for patients with chronic pain who require surgery that leads to acute and chronic pain). Many specialties are involved in chronic pain management, including neurology, neurosurgery, medicine, psychiatry, physical medicine, and physical therapy.

Critical Care Medicine

Critical care medicine has significantly increased in complexity over the 30 years it has been recognized as a distinct subspecialty of anesthesiology (see Chapter 41). Increasingly, data from large randomized clinical trials are used to develop patient care protocols.[2] The categorization of ICU patients is most often arranged by one or more specialties (e.g., medical, surgical, neurosurgical, cardiac). Because so many specialties can or need to be involved, the critical care medicine specialist may have his or her initial residency training in several different specialties, including anesthesiology, medicine, surgery, neurology, pulmonary medicine, nephrology, or emergency medicine. In many institutions, anesthesiologists are in local leadership roles in critical care medicine.

Pediatric Anesthesia

Since the 1980s, anesthesia residency training has included rotations in pediatric anesthesia (see Chapter 34), and separate pediatric anesthesia fellowships have been offered for

many years. However, subspecialty certification by the ABA has only been issued since 2013. In 2009, the ABA and the American Board of Pediatrics launched a combined integrated training program in both pediatrics and anesthesiology that would take 5 years instead of the traditional 6 years. In pediatric hospitals, the role of pediatric anesthesiologists is very clear. However, the practice (and staffing challenges) becomes more complex when pediatric and adult surgeries are performed in the same hospital. Typical questions include how young must a patient be when only pediatric anesthesiologists deliver anesthesia (i.e., instead of anesthesiologists whose practice is mostly adult patients)? How should anesthesia be covered when there are no pediatric anesthesiologists? In a few hospitals, pediatric anesthesiologists also manage patients in the pediatric ICUs.

Cardiac Anesthesia

Cardiac anesthesia rotations have been required in residency for many years, and elective cardiac anesthesia fellowships have been available for at least as long (see Chapters 25 and 26). In 2006, the ACGME began to accredit adult cardiothoracic anesthesia fellowships, which led to increasing structure and standardization of the fellowships, including the requirement for echocardiography training. Anesthesiologists can obtain certification from the National Board of Echocardiography for perioperative transesophageal echocardiography as well as adult echocardiography. This certification is commonly achieved by cardiac anesthesiologists.

Obstetric Anesthesia

Because of the unique physiology and patient care issues, and the painful nature of childbirth, obstetric anesthesia experiences have always been an essential component of anesthesia training programs (see Chapter 33). Similarly, anesthesia fellowship training in obstetric anesthesia has been offered for decades. In 2012, the ACGME began to accredit obstetric anesthesiology fellowships. Similar to the evolution of other ACGME anesthesia fellowships (i.e., critical care, pain medicine, pediatric anesthesia, and adult cardiothoracic anesthesia), this has resulted in standardized and structured training to develop future leaders in obstetric anesthesia. Currently, the ABA does not offer subspecialty certification in this area.

Other Surgical Areas of Anesthesia

Anesthesia for the remaining surgical specialties is not associated with another certification process, although non-ACGME fellowship training may be available. These subspecialties include cardiothoracic (Chapter 27), colon and rectal (Chapters 28 and 29), general surgery, neurological (Chapter 30), ophthalmic (Chapter 31), oral and maxillofacial, urology, vascular, as well as hospice and palliative (Chapter 35). Anesthesia for the remaining surgical subspecialties is frequently delivered by anesthesiologists without additional special training other than that provided by a standard anesthesiology residency. Often, institutional patient volume dictates whether specialized anesthesia teams can deliver anesthesia. For example, institutions with large outpatient or neurosurgical surgery may have separate specialized teams.

PERIOPERATIVE PATIENT CARE

Preoperative Evaluation

Perioperative care includes preoperative evaluation, preparation in the immediate preoperative period, intraoperative care, PACU, acute postoperative pain management (Chapter 40), and possibly ICU care. Beginning in the late 1990s to early 2000s, most surgical patients were required to arrive the morning of surgery rather than the night before. This change frequently dictated that the anesthesia preoperative evaluation be performed during the morning of surgery. However, with complex patient medical risks and surgical procedures, many institutions created a preoperative clinic that allowed patients to be evaluated one or more days before the day of surgery. These clinics have become quite sophisticated (see Chapter 13) and are often managed by anesthesiologists. Patients may be evaluated directly by anesthesiologists, or the anesthesiologist may oversee care provided by nurses or nurse practitioners. Periodically, a patient will need additional evaluation by the primary care physician or other specialists for specific patient care issues.

Operating Room Theaters

Operating room theaters are increasingly becoming management challenges (see Chapter 46). Matching operating room available time with predicted surgical complexity and length is an intellectual challenge in its own right.[1-4] "Throughput" is the term used to describe the efficiency of each patient's experience. For decades, surgical teams have been allowed to operate in two to three operating rooms at the same time. For the first time in decades, the risks of concurrent surgeries are being questioned.[5] Sometimes the throughput is delayed not because of the operating room availability but because of insufficient beds in the PACU. There are numerous steps in the perioperative pathway (e.g., preoperative evaluation, the accuracy of predicting length and complexity of surgical care, and patient flow in and out of PACUs) that can delay a patient's progress as scheduled. For example, patients may need to wait in the operating room when surgery is complete awaiting a bed in the PACU. Institutions are increasingly appointing perioperative or operating room directors who either manage the operating rooms or coordinate the entire perioperative process starting from the preoperative clinic until exit

from the PACU. These positions can be administratively challenging and require considerable skill and clinical savvy. Such jobs are frequently held by an anesthesiologist, although sometimes the director might be a surgeon, nurse, or hospital administrator.

Postanesthesia Care Unit

In a tertiary care hospital, the role of the PACU is pivotal (see Chapter 39). Not only are patients recovering from anesthesia and surgery, they also are receiving direction for appropriate care after their PACU time that spans from ICU to discharge. Even now, insufficient PACU beds are often a cause of delayed throughput in operating room theaters.[1-4] There are many scenarios that illustrate this basic problem. If the routine hospital beds are completely occupied, there is no place to transfer fully recovered patients in the PACU. If those patients stay in the PACU, there will then be no beds for patients who need recovery from operating room–based surgery and anesthesia. When this problem is anticipated, then surgery start times are delayed. In the future, as anesthesiologists take care of patients with more complex medical risks, more PACU beds will be required in hospitals. In addition to the quality of care, patient logistical management is key to the quality and efficiency of care in the perioperative period.

TRAINING AND CERTIFICATION IN ANESTHESIOLOGY

Postgraduate (Residency) Training in Anesthesiology

Postgraduate training in anesthesiology in the United States consists of 4 years of supervised experience in an approved program after the degree of doctor of medicine or doctor of osteopathy has been obtained. The first year of postgraduate training in anesthesiology consists of education in the fundamental clinical skills of medicine. The second, third, and fourth postgraduate years (clinical anesthesia years 1 to 3) are spent learning all aspects of clinical anesthesia, including subspecialty experience in obstetric anesthesia, pediatric anesthesia, cardiothoracic anesthesia, neuroanesthesia, anesthesia for outpatient surgery, recovery room care, regional anesthesia, and pain management. In addition to these subspecialty experiences, 4 months of training in critical care medicine is required. The duration and structure of anesthesiology education differ in countries around the world. Nevertheless, there is generalized international agreement on what constitutes adequate training in anesthesiology and its perioperative responsibilities.

The content of the educational experience during the clinical anesthesia years reflects the wide-ranging scope of anesthesiology as a medical specialty. Indeed, the anesthesiologist should function as the clinical pharmacologist and internist or pediatrician in the operating room. Furthermore, the scope of anesthesiology extends beyond the operating room to include acute and chronic pain management (see Chapters 40 and 44), critical care medicine (see Chapter 41), cardiopulmonary resuscitation (see Chapter 45), and research. More recently, anesthesia training programs have been given increasingly more flexibility. Programs can offer integrated residency and fellowship training, including options for significant research time. These more specialized training programs have the opportunity to produce leaders in subspecialty clinical areas and research. In addition, the ABA has supported the development of combined residency programs in anesthesia and internal medicine, anesthesia and pediatrics, and, most recently, anesthesia and emergency medicine. Clearly, anesthesia training programs are being encouraged to train anesthesiologists who can meet the challenges of the future.

Approximately 131 postgraduate training programs in anesthesiology are approved by the ACGME in the United States. Approved programs are reviewed annually by the Residency Review Committee (RRC) for Anesthesiology to ensure continued compliance with the published program requirements. The RRC for Anesthesiology consists of members appointed by the American Medical Association, the American Society of Anesthesiologists, and the ABA.

American Board of Anesthesiology

The ABA was incorporated as an affiliate of the American Board of Surgery in 1938. After the first voluntary examination, 87 physicians were certified as diplomates of the ABA. The ABA was recognized as an independent board by the American Board of Medical Specialties in 1941. To date, more than 30,000 anesthesiologists have been certified as diplomates of the ABA based on completing an accredited postgraduate training program, passing a written and oral examination, and meeting licensure and credentialing requirements. These diplomates are referred to as "board-certified anesthesiologists," and the certificate granted by the ABA is characterized as the primary certificate. Starting on January 1, 2000, the ABA, like most other specialty boards, began to issue time-limited certificates (10-year limit). To recertify, all diplomates must participate in a program designated Maintenance of Certification in Anesthesiology (MOCA). In 2016, this program was newly redesigned as MOCA 2.0. Diplomates whose certificates are not time limited (any certificate issued before January 1, 2000) may participate voluntarily in MOCA. The MOCA program emphasizes continuous self-improvement (cornerstone of professional excellence) and evaluation of clinical skills and practice performance to ensure quality, as well as public accountability. The components include (1) professionalism and professional standing (unrestricted state license), (2) lifelong learning and self-assessment (formal and informal continuing medical education [CME], including patient

safety), (3) assessment of knowledge, judgment, and skills (completing 30 MOCA minute pilot questions per calendar quarter), and (4) improvement in medical practice. This final component may include a variety of self-directed activities including simulation, quality improvement projects, or clinical pathway development.[6] Along with several other specialties, the ABA also issues certificates in pain medicine, critical care medicine, hospice and palliative medicine, sleep medicine, and pediatric anesthesiology to diplomates who complete 1 year of additional postgraduate training in the respective subspecialty, meet licensure and credentialing requirements, and pass a written examination. These certificates also have a 10-year time limit. Recertification requirements are continuing to evolve as part of the ABA transition to Maintenance of Certification in Anesthesiology for Subspecialties Program (MOCA-SUBS).

Credentialing and Privileging

After completing residency and joining the medical staff of a hospital, the anesthesiologist must undergo the credentialing and privileging process, which allows appropriate institutions to collect, verify, and evaluate all data regarding a clinician's professional performance. Recently, three new concepts were developed on a joint basis by the ACGME and the American Board of Medical Specialties. General competencies (i.e., patient care, medical/clinical knowledge, practiced-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice) are used by the medical staff to evaluate clinicians. Also, focused professional practice evaluation can be used to provide more thorough information about an individual clinician. The last new concept is ongoing professional practice evaluation. In essence, processes need to be developed to identify a problem as soon as possible.

OTHER ANESTHETIC PROVIDERS

Certified Registered Nurse Anesthetists

Certified registered nurse anesthetists (CRNAs) probably participate in more than 50% of the anesthetics administered in the United States, most often under the supervision of a physician. To become a CRNA, the candidate must earn a registered nurse degree, spend 1 year as a critical care nurse, and then complete 2 to 3 years of didactic and clinical training in the techniques of administration of anesthetics in an approved nurse anesthesia training program. The American Association of Nurse Anesthetists is responsible for the curriculum of nurse anesthesia training programs, as well as the establishment of criteria for certification as a CRNA. The activities of CRNAs frequently concern the intraoperative care of patients during anesthesia while working under the supervision (medical direction) of an anesthesiologist. This physician-nurse anesthetist team approach (anesthesia care team) is consistent with the concept that administration of anesthesia is the practice of medicine. In some situations CRNAs administer anesthesia without the supervision or medical direction of an anesthesiologist.

Anesthesiologist Assistants

Anesthesiologist assistants complete a graduate-level program (about 27 months) and receive a master of medical science in anesthesia from an accredited training program (currently Case Western Reserve University, Emory University School of Medicine, Nova Southeastern University, South University, and University of Missouri).[3,7] Anesthesiologist assistants work cooperatively under the direction of the anesthesiologist as members of the anesthesia care team to implement the anesthesia care plan.

QUALITY OF CARE AND SAFETY IN ANESTHESIA

Continuous Quality Improvement

Quality is a difficult concept to define in the practice of medicine. It is generally agreed, however, that attention to quality improves patient safety and satisfaction with anesthetic care. Although the specialty of anesthesiology has had such emphasis for a long time, the National Academies of Sciences, Engineering, and Medicine (formerly the Institute of Medicine) drew attention to these issues in medicine overall in 2000 with their report "To Err Is Human."[4,8] New frequently used words became a routine part of our vocabulary (e.g., metrics of competency, ongoing measurement, standardization, checklists, timeouts, system approaches, and practice parameters).[5,6,9,10] Quality improvement programs in anesthesia are often guided by requirements of The Joint Commission (formerly the Joint Commission on Accreditation of Healthcare Organizations [JCAHO]). Quality of care is evaluated by attention to (1) structure (personnel and facilities used to provide care), (2) process (sequence and coordination of patient care activities such as performance and documentation of a preanesthetic evaluation, and continuous attendance to and monitoring of the patient during anesthesia), and (3) outcome. A quality improvement program focuses on measuring and improving these three basic components of care. In contrast to quality assurance programs designed to identify "outliers," continuous quality improvement (CQI) programs take a "systems" approach in recognition of the fact that random errors are inherently difficult to prevent. System errors, however, should be controllable and strategies to minimize them should be attainable. A CQI program may focus on undesirable outcomes as a way to identify opportunities for improvement in the structure and process of care.

Improvement in quality of care is often measured by a decrease in the rate of adverse outcomes (see Chapter 48). However, the relative rarity of adverse outcomes in anesthesia makes measurement of improvement difficult. To complement outcome measurement, CQI programs may focus on critical incidents and sentinel events. Critical incidents (e.g., ventilator disconnection) are events that cause or have the potential to cause injury if not noticed and corrected in a timely manner. Measurement of the occurrence rate of important critical incidents may serve as a substitute for rare outcomes in anesthesia and lead to improvement in patient safety. Sentinel events are isolated events that may indicate a systematic problem (syringe swap because of poor labeling, drug administration error related to keeping unneeded medications on the anesthetic cart).

The key factors in the prevention of patient injury related to anesthesia are vigilance, up-to-date knowledge, and adequate monitoring. Obviously, it is important to follow the standards endorsed by the American Society of Anesthesiologists. In this regard, American anesthesiology has been a leader within organized medicine in the development and implementation of formal, published standards of practice. These standards have significantly influenced how anesthesia is practiced in the United States (e.g., practice parameters).[6,10]

The publicity and emphasis on quality and safety have been intense for several years, but sometimes the standards are not implemented as rapidly and completely as desired. Recently suggestions have been made to attach credentialing requirements and penalties for failure to adhere to the required practices.[7,11] (See also Chapter 48.)

ORGANIZATIONS WITH EMPHASIS ON ANESTHESIA QUALITY AND SAFETY

Anesthesia Patient Safety Foundation

The Anesthesia Patient Safety Foundation (APSF) was established under the administration of Ellison C. Pierce, Jr., MD, during his year as president of the American Society of Anesthesiologists.[8,12] Initial financial support for formation of the APSF was provided by the American Society of Anesthesiologists, and this financial support continues to the present. In addition, APSF receives financial support from corporations, specialty societies, and individual donors. The purpose of APSF is to "assure that no patient shall be harmed by anesthesia." To fulfill this mission, the APSF provides research grants to support investigations designed to provide a better understanding of preventable anesthetic injuries and promotes national and international communication of information and ideas about the causes and prevention of harm from anesthesia. A quarterly APSF newsletter is the most widely distributed anesthesia publication in the world and is dedicated to discussion of anesthesia patient safety issues. Anesthesiology is the only specialty in medicine with a foundation dedicated solely to issues of patient safety. The National Patient Safety Foundation, formed in 1997 by the American Medical Association, is modeled after the APSF.

Anesthesia Quality Institute

The Anesthesia Quality Institute (AQI) was formed in 2008 for the purpose of being a primary source of information for quality improvement in the practice of anesthesiology. It maintains data that can be used to "assess and improve patient care." Eventually, the AQI will be able to provide quality and safety data that could be used to meet regulatory requirements. The AQI is already being used as a source of data for clinical care, research, and societies that have improving quality of care as a goal. The AQI website describes the structure of the National Anesthesia Clinical Outcomes Registry (NACOR) and how data flow into and out of the AQI.[13]

American Society of Anesthesiologists Closed Claims Project and Its Registries

The ASA Closed Claims Project and its Registries are a database of retrospective analyses of legal cases with adverse outcomes. This ongoing investigation has helped identify patient and practice risk areas that tend to have difficulties and require added attention from the specialty with regard to quality and safety.[5,9]

Foundation for Anesthesia Education and Research

Although not directly involved with quality and safety, the Foundation for Anesthesia Education and Research (FAER) is an exceptionally important vehicle for support of research in the specialty of anesthesiology. FAER was established in 1986 with financial support from the American Society of Anesthesiologists. In addition, FAER receives financial support from corporations, specialty societies, and individual donors. The purpose of FAER is to encourage research, education, and scientific innovation in anesthesiology, perioperative medicine, and pain management. Over the years, FAER has funded numerous research grants and provided support for the development of academic anesthesiologists.

PROFESSIONAL LIABILITY

Because of intense dedication to quality and safety, malpractice claims have been reduced both in frequency and magnitude. As a result, malpractice premiums have dramatically decreased over the last 20 years. Nevertheless the fundamental principles need to be understood. First,

litigation still occurs. For example, 93 claims were filed in the United Kingdom over the years 1995 to 2007.[9,14] Sixty-two claims involved alleged drug administration errors in which muscle relaxants were the most common issue. Also, 19 claims involved patients being awake and paralyzed (see Chapter 47). With proper labeling and double-checking, such errors can be decreased. The anesthesiologist is clearly responsible for management and recovery from anesthesia. Physicians administering anesthetics are not expected to guarantee a favorable outcome to the patient but are required to exercise ordinary and reasonable care or skill in comparison to other anesthesiologists. That the anticipated result does not follow or that complications occur does not imply negligence (practice below the standard of care). Furthermore, an anesthesiologist is not responsible for an error in judgment unless it is viewed as inconsistent with the skill expected of every physician. As a specialist, however, an anesthesiologist is responsible for making medical judgments that are consistent with national, not local, standards. Anesthesiologists maintain professional liability (malpractice) insurance that provides financial protection in the event of a court judgment against them. Also, CRNAs can be held legally responsible for the technical aspects of the administration of anesthesia. It is likely, however, that legal responsibility for the actions of the CRNA will be shared by the physician responsible for supervising the administration of anesthesia.

The best protection for the anesthesiologist against medicolegal action lies in the thorough and up-to-date practice of anesthesia, coupled with interest in the patient by virtue of preoperative and postoperative visits plus detailed records of the course of anesthesia (automated information systems provide the resource to collect and record real-time actual data). Also, all anesthesia providers should be prepared to transition to anesthesia record keeping via automated information systems. Specifically, use of automated anesthetic records should be fully integrated into one's medical center information technology system. Unfortunately, implementation of electronic health records (EHRs) is difficult, costly, time-consuming, and fraught with many unintended consequences, including not meeting safety standards. However, a review of 2008-2014 national data reveals large gains in using EHRs with 75% of hospitals having at least a basic EHR system, up from 59% in 2013.[15] In the United States, at the forefront of implementation and use of health information technology is the Office of the National Coordinator (ONC) for Health Information Technology.

Adverse Events

In the event of an accident or complication related to the administration of anesthesia, the anesthesiologist should promptly document the facts on the patient's medical record (see the APSF Adverse Event Protocol[16]) and immediately notify the appropriate agencies, beginning at the department level and continuing with one's own medical center quality improvement administration and risk management office. Patient treatment should be noted and consultation with other physicians sought when appropriate. The anesthesiologist should provide the hospital and the company that writes the physician's professional liability insurance with a complete account of the incident. The investigation and discussion of adverse events and complications may involve a root cause analysis (RCA) in collaboration with the physicians, nurses, and other staff involved with the patient's care.

RISKS OF ANESTHESIA

Although patients may express a fear of dying during anesthesia, the fact is that anesthesia-related deaths have decreased dramatically in the last 2 decades.[11,17] Because fewer adverse events are being attributed to anesthesia, the professional liability insurance premiums paid by anesthesiologists have decreased.[12,18] The increased safety of anesthesia (especially for patients without significant coexisting diseases and undergoing elective surgery) is presumed to reflect the introduction of improved anesthesia drugs and monitoring (pulse oximetry, capnography), as well as the training of increased numbers of anesthesiologists. Despite the perceived safety of anesthesia, adverse events still occur, and not all agree that the mortality rate from anesthesia has improved as greatly as suggested. Improvement is based on a series of 244,000 surviving patients who underwent anesthesia and surgery. This series is the basis for estimating a mortality rate from anesthesia of 1 in 250,000.[14,19] It is likely that the safety of anesthesia and surgery can be improved by persuading patients to stop smoking, lose weight, avoid excess intake of alcohol, and achieve optimal medical control of essential hypertension, diabetes mellitus, and asthma before undergoing elective operations.

When perioperative adverse events occur, it is often difficult to establish a cause-and-effect mechanism. In many instances it is impossible to separate an adverse event caused by an inappropriate action of the anesthesiologist ("lapse of vigilance," breach in the standard of care) from an unavoidable mishap (maloccurrence, coincidental event) that occurred despite optimal care.[15,20] Examples of adverse outcomes other than death include peripheral nerve damage, brain damage, airway trauma (most often caused by difficult tracheal intubation), intraoperative awareness, eye injury, fetal/newborn injury, and aspiration. Difficult airway management has traditionally been perceived by anesthesiologists as the greatest anesthesia patient safety issue.[17,21] A survey of

Box 1.1 Patient Safety Concerns of Anesthesiologists in Large Group Practices

1. Distractions in the operating room
2. Production pressures
3. Communication (handoffs)
4. Medication safety
5. Postoperative respiratory monitoring, neuromuscular blocker monitoring

From Stoelting RK. Large anesthesia/practice management groups: how can APSF help everyone be safer? *APSF Newsletter.* 2016;30(3):45, 55-56. http://www.apsf.org.

large anesthesia groups has highlighted other concerns to patient safety (Box 1.1).

Improved monitoring of anesthetized patients hopefully will serve to further enhance the vigilance of the anesthesiologist and decrease the role of human error in anesthetic morbidity and mortality rates. Indeed, human error, in part resulting from lapses in attention (vigilance), accounts for a large proportion of adverse anesthesia events. A number of factors at work in the operating room environment serve to diminish the ability of the anesthesiologist to perform the task of vigilance. Prominent among these factors are sleep loss and fatigue with known detrimental effects on work efficiency and cognitive tasks (monitoring, clinical decision making). The RRC for Anesthesiology mandates that anesthesia residents not be assigned clinical responsibilities the day after 24-hour in-hospital call. The Health and Medicine Division (HMD) of the National Academies has made very specific recommendations regarding resident work hours and will no doubt make recommendations for physicians overall that could eventually be mandated. The emphasis on efficiency in the operating room ("production pressures") designed to improve productivity may supersede safety and provoke the commission of errors that jeopardize patient safety. At the same time, not all adverse events during anesthesia are a result of human error and therefore preventable.

HAZARDS OF WORKING IN THE OPERATING ROOM

Anesthesiologists spend long hours in an environment (operating room) associated with exposure to vapors from chemicals (volatile anesthetics), ionizing radiation, and infectious agents (hepatitis viruses, human immunodeficiency virus). There is psychological stress from demands of the constant vigilance required for the care of patients during anesthesia. Furthermore, interactions with members of the operating team (surgeons, nurses) may introduce varying levels of interpersonal stress. Removal of waste anesthetic gases (scavenging) has decreased exposure to trace concentrations of these gases, although evidence that this practice has improved the health of anesthesia personnel is lacking. Universal precautions are recommended in the care of every patient in an attempt to prevent the transmission of blood-borne infections, particularly by accidental needlestick injuries. Substance abuse, mental illness (depression), and suicide seem to occur with increased frequency among anesthesiologists, perhaps reflecting the impact of occupational stress.

Lastly, infection control for both patients and clinical personnel in the operating rooms require increasingly strict rules regarding specific procedures in the operating room such as washing hands.

SUMMARY AND FUTURE OUTLOOK

This chapter reflects the constantly evolving and changing practice of anesthesia. Our responsibilities have grown in magnitude, scope, and depth. Although anesthesia practice is partly based on outpatient activities (see Chapters 37 and 44), it has also become a leading specialty with regard to inpatient medicine, especially the perioperative period including critical care medicine (see Chapter 41). Definitely more sophisticated technological tools and systems will be integrated in the practice of anesthesiology. In more recent years, the use of robots in the operating theater has become standard for specific surgeries.[18,22] The specialty will become even more valuable to medicine overall by attempting to anticipate future societal needs[15,20] and continuing to dedicate ourselves to the pursuit of excellence.[10] Lastly, this chapter has described the American organization and delivery of anesthesia. Every country in the world has or should subject their anesthesia practice to an intense and possibly similar type of analysis.

QUESTIONS OF THE DAY

1. In the United States, which anesthesiology fellowships are accredited by the Accreditation Council for Graduate Medical Education? What is the impact of Accreditation Council for Graduate Medical Education accreditation on the structure of a fellowship program?
2. What are the sources of data in the National Anesthesia Clinical Outcomes Registry?
3. How has the Foundation for Anesthesia Education and Research helped to advance the specialty of anesthesiology?
4. What are the reasons for a decrease in anesthesia malpractice premiums over the past few decades? What steps can the anesthesia provider take to reduce the chance for a lawsuit after an adverse event?
5. What are the potential hazards of working in the operating room as an anesthesia provider?

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Chapter

2 LEARNING ANESTHESIA

Manuel C. Pardo, Jr.

The challenges of learning perioperative anesthesia care have grown considerably as the specialty, and medicine in general, have evolved. The beginning anesthesia trainee is faced with an ever-increasing quantity of knowledge, the need for adequate patient care experiences, and increased attention to patient safety as well as cost containment.[1] Most training programs begin with close clinical supervision by an attending anesthesiologist. More experienced trainees may offer their perspectives and practical advice. Some programs use a mannequin-based patient simulator or other forms of simulation to facilitate the learning process.[2] The practice of anesthesia involves the development of flexible patient care routines, factual and theoretical knowledge, manual and procedural skills, and the mental abilities to adapt to changing situations.[3]

COMPETENCIES AND MILESTONES

The anesthesia provider must be skilled in many areas. The Accreditation Council for Graduate Medical Education (ACGME) developed its Outcome Project, which includes a focus on six core competencies: patient care, medical knowledge, professionalism, interpersonal and communication skills, systems-based practice, and practice-based learning and improvement (Table 2.1).[4] More recently, the ACGME has advanced the core competencies approach by adopting the Dreyfus model of skill acquisition to create a framework of "milestones" in the development of anesthesia residents during 4 years of training.[5,6] Table 2.2 shows an example of a milestone in the patient care competency. The milestones incorporate several aspects of residency training, including a description of expected behavior, the complexity of the patient and the surgical procedure, and the level of supervision needed by the resident.

Table 2.1 Competencies in Anesthesia Care

Procedure Event/ Problem	Competency
Perform preoperative history and physical	Patient care, communication
Determine dose of neuromuscular blocking drug to facilitate tracheal intubation	Medical knowledge
Perform laryngoscopy and tracheal intubation	Patient care
Interact with surgeons and nurses in operating room	Professionalism, communication
Manage maintenance and emergence from anesthesia	Patient care
Patient with dental injury: refer to quality assurance committee	Systems-based practice
Patient with postoperative nausea: compare prophylaxis strategy with published literature	Practice-based learning and improvement

STRUCTURED APPROACH TO ANESTHESIA CARE

Anesthesia providers care for the surgical patient in the preoperative, intraoperative, and postoperative periods (Box 2.1). Important patient care decisions reflect on assessing the preoperative evaluation, creating the anesthesia plan, preparing the operating room, and managing the intraoperative anesthetic, postoperative care, and outcome. An understanding of this framework will facilitate the learning process.

Preoperative Evaluation

The goals of preoperative evaluation include assessing the risk of coexisting diseases, modifying risks, addressing patients' concerns, and discussing options for anesthesia care (see Chapters 13 and 14). The beginning trainee should learn the types of questions that are the most important to understanding the patient and the proposed surgery. Some specific questions and their potential importance follow.

What is the indication for the proposed surgery? Is it elective or an emergency? The indication for surgery may have particular anesthetic implications. For example,

Table 2.2 Example of Anesthesia Resident Milestones: Patient Care Competency, Anesthetic Plan, and Conduct

Level 1	Level 2	Level 3	Level 4	Level 5
Formulates patient care plans that include consideration of underlying clinical conditions, past medical history, and patient, medical, or surgical risk factors Adapts to new settings for delivery of patient care	Formulates anesthetic plans for *patients undergoing routine procedures* that include consideration of underlying clinical conditions, past medical history, patient, anesthetic and surgical risk factors, and patient choice Conducts *routine* anesthetics, including management of commonly encountered physiologic alterations associated with anesthetic care, with *indirect supervision*	Formulates anesthetic plans for *patients undergoing common subspecialty procedures* that include consideration of medical, anesthetic, and surgical risk factors and that take into consideration a patient's anesthetic preference Conducts *subspecialty* anesthetics with *indirect supervision* but may require *direct supervision for more complex* procedures and patients	Formulates and tailors anesthetic plans that include consideration of medical, anesthetic, and surgical risk factors and patient preference for *patients with complex medical issues undergoing complex procedures with conditional independence* Conducts *complex* anesthetics with *conditional independence; may supervise others* in the management of complex clinical problems	*Independently* formulates anesthetic plans that include consideration of medical, anesthetic, and surgical risk factors as well as patient preference for *complex patients and procedures* Conducts *complex* anesthetic management *independently*

Levels correspond to the following time points during residency:
Level 1: Resident has completed one postgraduate year of education.
Level 2: Resident is without significant experience in subspecialties of anesthesiology.
Level 3: Resident has experience in subspecialties of anesthesiology.
Level 4: Resident substantially fulfills milestones expected of an anesthesiology residency; designated as graduation target.
Level 5: Resident has advanced beyond performance targets defined for residency and is demonstrating "aspirational" goals.
From Anesthesiology Residency Review Committee. The Anesthesiology Milestone Project. https://www.acgme.org/Portals/0/PDFs/Milestones/AnesthesiologyMilestones.pdf. July 2015. Accessed May 2, 2016.

Box 2.1 Phases of Anesthesia Care

Preoperative Phase
Preoperative evaluation
Choice of anesthesia
Premedication

Intraoperative Phase
Physiologic monitoring and vascular access
General anesthesia (i.e., plan for induction, maintenance, and emergence)
Regional anesthesia (i.e., plan for type of block, needle, local anesthetic)

Postoperative Phase
Postoperative pain control method
Special monitoring or treatment based on surgery or anesthetic course
Disposition (e.g., home, postanesthesia care unit, ward, monitored ward, step-down unit, intensive care unit)
Follow-up (anesthesia complications, patient outcome)

a patient requiring esophageal fundoplication will likely have severe gastroesophageal reflux disease, which may require modification of the anesthesia plan (e.g., preoperative nonparticulate antacid, intraoperative rapid-sequence induction of anesthesia).

A given procedure may also have implications for anesthetic choice. Anesthesia for hand surgery, for example, can be accomplished with local anesthesia, peripheral nerve blockade, general anesthesia, or sometimes a combination of techniques. The urgency of a given procedure (e.g., acute appendicitis) may preclude lengthy delay of the surgery for additional testing, without increasing the risk of complications (e.g., appendiceal rupture, peritonitis).

What are the inherent risks of this surgery? Surgical procedures have different inherent risks. For example, a patient undergoing coronary artery bypass graft has a significant risk of problems such as death, stroke, or myocardial infarction. A patient undergoing cataract extraction has an infrequent risk of major organ damage.

Does the patient have coexisting medical problems? Does the surgery or anesthesia care plan need to be modified because of them? To anticipate the effects of a given medical problem, the anesthesia provider must understand the physiologic effects of the surgery and anesthetic and the potential interaction with the medical problem. For example, a patient with poorly controlled systemic hypertension is more likely to have an exaggerated hypertensive response to direct laryngoscopy to facilitate tracheal intubation. The anesthesia provider may change the anesthetic plan to increase the induction dose of intravenously administered anesthetic (e.g., propofol) and administer a short-acting β-adrenergic blocker (e.g., esmolol) before instrumentation of the airway. Depending on the medical problem, the anesthesia plan may require modification during any phase of the procedure.

Has the patient had anesthesia before? Were there complications such as difficult airway management? Does the patient have risk factors for difficult airway management? Anesthesia records from previous surgery can yield much useful information. The most important fact is the ease of airway management techniques such as direct laryngoscopy. If physical examination reveals some risk factors for difficult tracheal intubation, but the patient had a clearly documented uncomplicated direct laryngoscopy for recent surgery, the anesthesia provider may choose to proceed with routine laryngoscopy. Other useful historical information includes intraoperative hemodynamic and respiratory instability and occurrence of postoperative nausea.

Creating the Anesthesia Plan

After the preoperative evaluation, the anesthesia plan can be completed. The plan should list drug choices and doses in detail, as well as anticipated problems (Boxes 2.2 and 2.3). Many variations on a given plan may be acceptable, but the trainee and the supervising anesthesia provider should agree in advance on the details.

Preparing the Operating Room

After determining the anesthesia plan, the trainee must prepare the operating room (Table 2.3). Routine operating room preparation includes tasks such as checking the anesthesia machine (see Chapter 15). The specific anesthesia plan may have implications for preparing additional equipment. For example, fiberoptic tracheal intubation requires special equipment that may be kept in a cart dedicated to difficult airway management.

Managing the Intraoperative Anesthetic

Intraoperative anesthesia management generally follows the anesthesia plan but should be adjusted based on the patient's responses to anesthesia and surgery. The anesthesia provider must evaluate a number of different information pathways from which a decision on whether to change the patient's management can be made. The trainee must learn to process these different information sources and attend to multiple tasks simultaneously. The general cycle of mental activity involves observation, decision making, action, and repeat evaluation. Vigilance—being watchful and alert—is necessary for safe patient care, but vigilance alone is not enough. The anesthesia provider must weigh the significance of each observation and can become overwhelmed by the amount of information or by rapidly changing information. Intraoperative clinical events can stimulate thinking and promote an interactive discussion between the trainee and supervisor (Table 2.4).

Box 2.2 Sample General Anesthesia Plan

Case
A 47-year-old woman with biliary colic and well-controlled asthma requires anesthesia for laparoscopic cholecystectomy.

Preoperative Phase
Premedication:
Midazolam, 1-2 mg intravenous (IV), to reduce anxiety
Albuterol, two puffs, to prevent bronchospasm

Intraoperative Phase
Vascular Access and Monitoring
Vascular access: one peripheral IV catheter
Monitors: pulse oximetry, capnography, electrocardiogram, noninvasive blood pressure with standard adult cuff size, temperature

Induction
Propofol, 2 mg/kg IV (may precede with lidocaine, 1 mg/kg IV)
Neuromuscular blocking drug to facilitate tracheal intubation (succinylcholine, 1-2 mg/kg IV) or nondepolarizing neuromuscular blocking drugs (rocuronium, 0.6 mg/kg)
Airway management
Face mask: adult medium size
Direct laryngoscopy: Macintosh 3 blade, 7.0-mm internal diameter (ID) endotracheal tube

Maintenance
Inhaled anesthetic: sevoflurane or desflurane
Opioid: fentanyl, anticipate 2-4 μg/kg IV total during procedure
Neuromuscular blocking drug titrated to train-of-four monitor (peripheral nerve stimulator) at the ulnar nerve[a]

Emergence
Antagonize effects of nondepolarizing neuromuscular blocking drug: neostigmine, 70 μg/kg, and glycopyrrolate, 14 μg/kg IV, titrated to train-of-four monitor
Antiemetic: dexamethasone, 4 mg IV, at start of procedure; ondansetron, 4 mg IV, at end of procedure
Tracheal extubation: when patient is awake, breathing, and following commands
Possible intraoperative problem and approach:
Bronchospasm: increase inspired oxygen and inhaled anesthetic concentrations, decrease surgical stimulation if possible, administer albuterol through endotracheal tube (5-10 puffs), adjust ventilator to maximize expiratory flow

Postoperative Phase
Postoperative pain control: patient-controlled analgesia—hydromorphone, 0.2 mg IV; 6-min lockout interval, do not use basal rate
Disposition: postanesthesia care unit, then hospital ward

[a]Nondepolarizing neuromuscular blocking drug choices include rocuronium, vecuronium, pancuronium, atracurium, and cisatracurium.

Box 2.3 Sample Regional Anesthesia Plan

Case
A 27-year-old man requires diagnostic right shoulder arthroscopy for chronic pain. He has no known medical problems.

Preoperative Phase
Premedication: midazolam, 1-2 mg intravenous (IV), to reduce anxiety

Intraoperative Phase
Type of block: interscalene
Needle: 22-gauge short-bevel, 5 cm long
Local anesthetic: 1.5% mepivacaine, 25 mL
Ancillary equipment: ultrasound machine with linear transducer, sterile sheath, ultrasound gel
Technique: chlorhexidine skin preparation, localize nerve in posterior triangle of neck, use ultrasound to guide in-plane needle insertion, inject local anesthetic
Intraoperative sedation and analgesia:
Midazolam, 0.5-1 mg IV, given every 5-10 minutes as indicated
Fentanyl, 25-50 μg IV, given every 5-10 minutes as indicated

Postoperative Phase
Postoperative pain control: when block resolves, may treat with fentanyl, 25-50 μg IV, as needed
Disposition: postanesthesia care unit, then home

Patient Follow-up

The patient should be reassessed after recovery from anesthesia. This follow-up includes assessing general satisfaction with the anesthetic, as well as a review for complications such as dental injury, nausea, nerve injury, and intraoperative recall. There is increasing attention on the long-term impact of anesthesia, including the impact of "deep" levels of anesthesia, hypotension, and inhaled anesthetic dose on postoperative mortality rate.[7]

LEARNING STRATEGIES

Learning during supervised direct patient care is the foundation of clinical training. Because the scope of anesthesia practice is so broad (see Chapter 1) and the competencies trainees are required to master are diverse, direct patient care cannot be the only component of the teaching program. Other modalities include lectures, group discussions, simulations, and independent reading. Lectures can be efficient methods for transmitting large amounts of information. However, the lecture format is not conducive to large amounts of audience interaction. Group discussions are most effective when they are small (fewer than 12 participants) and interactive. Journal clubs, quality assurance conferences, and problem-based case discussions lend themselves to this format. A teaching method termed *the flipped classroom* can combine aspects of lectures and group discussions.[8] One popular approach to the flipped classroom involves use of an online video lecture that must be viewed prior to the class session. Class time involves discussions or other active learning modalities that are only effective if the trainee has viewed the material beforehand. Simulations can

Table 2.3 Operating Room Preparation

Components	Preparation Tasks/Supplies and Equipment
Basic Room Setup	
Suction (S)	Check that suction is connected, working, and near the head of the bed.
Oxygen (O)	Check oxygen supply pressures (pipeline of approximately 50 psi and E-cylinder of at least 2000 psi). Check anesthesia machine (do positive-pressure circuit test).
Airway (A)	Two laryngoscope blades and handles
	Two endotracheal tubes of different sizes (one with and one without a stylet)
	Two laryngeal mask airways (LMA 3 and LMA 4)
	Two oral airways
	Two nasal airways
	Lidocaine or K-Y jelly
	Bite block and tongue depressor
	Tape
Intravenous access (I)	Two catheter sizes
	1-mL syringe with 1% lidocaine
	Tourniquet, alcohol pads, gauze, plastic dressing, tape
Monitors (M)	Electrocardiographic pads
	Blood pressure cuff (correct size for patient)
	Pulse oximeter probe
	Capnography monitor (breathe into circuit to confirm function)
	Temperature probe
Daily Drugs to Prepare	
Premedicants	Midazolam, 2 mL at 1 mg/mL
Opioids	Fentanyl, 5 mL at 50 µg/mL
Induction drugs	Propofol, 20 mL at 10 mg/mL
	or
	Thiopental, 20 mL at 25 mg/mL
	Etomidate, 20 mL at 2 mg/mL
Neuromuscular blocking drugs	Succinylcholine, 10 mL at 20 mg/mL
	Rocuronium, 5 mL at 10 mg/mL
Vasopressors	Ephedrine, 10 mL at 5 mg/mL (dilute 50 mg/mL in 9 mL of saline)
	Phenylephrine, 10 mL at 100 µg/mL (dilute 10 mg in 100 mL of saline)
Avoiding Drug Errors	
Tips for prevention	Look twice at the source vial being used to prepare your drug.
	Some vials look alike, and some drug names sound the same. Always label your drugs as soon as they are prepared. Write the following on the label: drug name and concentration, date, time, your initials.
	Discard unlabeled syringes.
Conversion of % to mg/mL	Move decimal point one place to the right (1.0% = 10 mg/mL).
	By definition, 1% = 1 g/100 mL.
	1% lidocaine is 1000 mg/100 mL, or 10 mg/mL.
Conversion of 1:200,000	Memorize: 1:200,000 is 5 µg/mL (1:1000 is 1000 µg/mL or 1 mg/mL).

Table 2.4 Examples of Intraoperative Events to Discuss

Event	Questions to Consider	Possible Discussion Topics
Tachycardia after increase in surgical stimulation	Is the depth of anesthesia adequate? Could there be another cause for the tachycardia? Is the patient in sinus rhythm or could this be a primary arrhythmia?	Assessment of anesthetic depth Approaches to increasing depth of anesthesia Diagnosis of tachycardia
End-tidal CO_2 increases after laparoscopic insufflation	Is the patient having a potentially life-threatening complication of laparoscopy such as CO_2 embolism? What is the expected rise in end-tidal CO_2 with laparoscopic procedures? How should the mechanical ventilator settings be adjusted?	Complications of laparoscopy Mechanical ventilation modes Causes of intraoperative hypercarbia
Peripheral nerve stimulator indicates train-of-four 0/4 15 minutes prior to end of surgery	Is the nerve stimulator functioning properly? Is there a reason for prolonged neuromuscular blockade? Can the blockade be reversed safely?	Neuromuscular stimulation patterns Clinical implications of residual neuromuscular blockade Pharmacology of neuromuscular blockade reversal

take several forms: task-based simulators to practice discrete procedures such as laryngoscopy or intravenous catheter placement, mannequin-based simulators to recreate an intraoperative crisis such as malignant hyperthermia or cardiac arrest, and computer-based simulators designed to repetitively manage advanced cardiac life support algorithms. Independent reading should include basic textbooks and selected portions of comprehensive textbooks as well as anesthesia specialty journals and general medical journals.

The beginning trainee is typically focused on learning to care for one patient at a time, that is, case-based learning. When developing an individual anesthesia plan, the trainee should also set learning goals for a case. For example, the patient in Box 2.2 has a history of asthma and requires laparoscopic surgery. Several questions could become topics for directed reading before the case or discussion during the case. *What complications of laparoscopic surgery can present intraoperatively? What are the manifestations? How should they be treated? How will the severity of the patient's asthma be assessed? What if the patient had wheezing and dyspnea in the preoperative area?* Trainees should regularly reflect on their practice and on how they can improve their individual patient care and their institution's systems of patient care.

Learning Orientation Versus Performance Orientation

The trainee's approach to a learning challenge can be described as a "performance orientation" or a "learning orientation."[9] Trainees with a performance orientation have a goal of validating their abilities, while trainees with a learning orientation have the goal of increasing their mastery of the situation. Feedback is more likely to be viewed as beneficial for trainees with a learning orientation, while a trainee with a performance orientation is likely to view feedback as merely a mechanism to highlight an area of weakness. If the training setting is challenging and demanding, an individual with a strong learning orientation is more likely to thrive.

TEACHING ANESTHESIA

The role of residents as teachers is increasingly recognized as crucially important to the training of medical students.[10] Residents will spend a significant amount of their time in teaching activities, even early in their own training. Many specialties have developed curricula to address this teaching role, which has a positive impact on both resident and student. One published approach consists of a series of workshops focused on six teaching skills: giving feedback, teaching around the case, orienting a learner, teaching a skill, teaching at the bedside, and delivering a minilecture.[11]

A clinical teaching approach that has been well described in several specialties is called the *One-Minute Preceptor* model.[12] It describes five sequential steps that can be used to structure brief clinical encounters. Table 2.5 lists the steps and an example relevant to an anesthesia student clerkship.

Table 2.5 Example of One-Minute Preceptor Teaching Model in Anesthesia

You are working with a medical student on an anesthesia rotation. An otherwise healthy patient is receiving general anesthesia for laparoscopic cholecystectomy. After CO_2 insufflation and placement of the patient in Trendelenburg (head-down) position, the oxygen saturation decreases from 100% to 93%.

Steps in Teaching	Dialogue With Student
Step 1. Get a commitment	Why do you think the oxygen saturation is decreasing?
Step 2. Probe for supporting evidence	What findings suggest that the endotracheal tube position changed?
Step 3. Teach general rules	Discuss how to approach acute hypoxemia during general anesthesia.
Step 4. Reinforce what was done well	You astutely observed other signs of endobronchial intubation such as elevated peak airway pressure.
Step 5. Correct mistakes	In the future, you would not give empiric bronchodilator therapy unless there are more definitive signs of bronchospasm.

QUESTIONS OF THE DAY

1. What is a "milestone" in the context of anesthesia residency training?
2. How would you adapt the sample general anesthesia plan in Box 2.2 if the patient had poorly controlled asthma and required emergency laparoscopic appendectomy?
3. What are the components of the One-Minute Preceptor teaching model?
4. You are working with a new anesthesia learner. How could you use the structure of Table 2.4 to develop questions and discussion topics for the following event: a healthy patient develops hypotension after induction of anesthesia and tracheal intubation?

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Chapter

3 ANESTHESIA AND HEALTH INFORMATION TECHNOLOGY

David Robinowitz and Scott Springman

Anesthesia providers produce and record extraordinary amounts of physiologic, pharmacologic, and care management information. Since the previous edition of this text was published in 2011, there has been exponential growth in the use of computerized anesthesia information management systems (AIMS) both as a stand-alone system and as part of an overall patient care electronic health record (EHR). In the late 1990s, only a handful of academic anesthesia practices had an AIMS installation, with even fewer in private practice settings. However, by 2007 approximately 44% of academic medical centers had completed or were in the process of implementing AIMS. A 2014 follow-up survey estimated that 84% of U.S. academic medical centers would have an AIMS installed by the end of that year. The prediction was that within a few years, few anesthesia trainees would graduate from residency having used a paper anesthetic record.[1] EHRs will likely incorporate the growing number of adjunct electronic devices and other software, combining all into the global term *health information technology*, or *health IT*. Given the enormous impact of health IT on patient care, anesthesia providers must have an understanding of these technologies including their potential benefits and hazards. The scientific discipline that serves as the foundation of health IT is *medical informatics* (the branch of information science that relates to health care and biomedicine), which encompasses health informatics, medical computer science, and computers in medicine.

Given their special skills and knowledge, anesthesia providers should be key players in the development, assessment, selection, and deployment of perioperative health IT. Anesthesia teams now need a working knowledge of the applicable theory and practice of medical informatics. In this chapter, several key health IT topics

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for the anesthesia provider will be reviewed, with a focus on AIMS, including some considerations for managing the procurement and operation of information technology in an anesthetic practice.

HISTORY OF ANESTHESIA DOCUMENTATION AND AIMS

The origins of the modern AIMS date back to the creation of the paper record in 1895 by neurosurgeon and physiologist Harvey Cushing and his medical school classmate E.A. Codman.[2] As pioneers of anesthesia quality improvement, Codman and Cushing had challenged each other to improve their anesthesia practice. In support of this goal, they were the first to collect and review physiologic data using written anesthesia records just 50 years after the discovery of anesthesia. About the same time, Cushing and others began to employ newly invented automated hemodynamic monitors with paper-based recordings, including noninvasive arterial blood pressure measurements. Over the subsequent 50 years, the anesthetic record maintained the same basic format for representation of hemodynamics, albeit with a slow and steady increase in the amount and types of data recorded. These two innovations—documentation of significant events during actual anesthesia and surgery coupled with automated real-time recordings of hemodynamic vital signs—formed the foundation of the modern AIMS.

The late 1970s and early 1980s saw the rollout and initial evaluation of the computerized anesthesia automated record keeper (AARK), but commercialization and widespread adoption were slowed by the limited availability of cheap and reliable computer hardware and software.[3] Yet, many benefits of AARKs became apparent, even within the limitations of this nascent technology. AARKs corrected limitations of paper records such as recall bias, illegible records, missing data or whole records (with regulatory and billing implications), and the lack of an audit trail for medical/legal purposes. Clinical studies of AARKs also revealed that they produced a more accurate record of hemodynamic variables than handwritten charts.[4] For instance, handwritten anesthetic records had increased "data smoothing" (i.e., recorded data were often approximated, leading to less variation between individually recorded data points) as compared to AARKs.

The 1990s and early 2000s heralded a proliferation of advanced computer hardware and software, such as local area networks, the Internet, digital hemodynamic monitors, medical communication protocols such as Health Level Seven International (HL7), and a significant reduction in the cost of computer processing power. Coupled with the voracious demand for more data that paper records could not satisfy, the relatively simple AARKs evolved into full-fledged AIMS, with numerous additional capabilities.

THE DEMAND FOR DATA

In 2001, the Anesthesia Patient Safety Foundation (APSF) endorsed and advocated "the use of automated record keeping in the perioperative period and the subsequent retrieval and analysis of the data to improve patient safety."[5] There were also demands for anesthesia and perioperative data for such purposes as compliance documentation, research, quality assurance, and the streamlining of billing and administrative functions. However, U.S. federal government action may have most catalyzed the rapid pace of EHR adoption in this country in the 21st century. The Health Information Technology for Economic and Clinical Health (HITECH) Act, enacted as part of the American Recovery and Reinvestment Act of 2009, encouraged the adoption and appropriate use of health IT, including provisions for monetary incentives and penalties.

In 2011, the U.S. Department of Health and Human Services (HHS) Centers for Medicare & Medicaid Services (CMS) initiated the Medicare and Medicaid EHR Incentive Programs. Their Meaningful Use (MU) criteria encourage U.S. health care providers and organizations to adopt health IT through a staged process, via variable payments or penalties. For ongoing MU compliance, organizations must—by 2017—satisfy Stage 3 rules, which consolidate and update many of the Stage 1 and 2 requirements, as well as add requirements for privacy and security practices and the electronic submission of clinical quality measure (CQM) data for all providers (Box 3.1). Reporting compliance within the MU system is complex. For instance, there are specific reporting, incentive, and hardship exemption rules that may apply to anesthesia providers. Advice from the American Society of Anesthesiologists, HHS, Office of the National Coordinator for Health Information Technology (ONC), and health IT professionals may help navigate these requirements.[6,7] The requirements are dynamic, and in early 2016, in response to stakeholder feedback, the federal government was developing the Advancing Care Information program. This new program's intent is to simplify or replace the MU program, focusing on improving interoperability (see later) and creating user-friendly technology designed to support physician workflows. Up-to-date information about federal guidelines and requirements for health IT is available online.[8]

Box 3.1 Objectives and Measures for Meaningful Use in 2017 and Beyond

- Protect patient health information
- Electronic prescribing (eRx)
- Clinical decision support (CDS)
- Computerized provider order entry (CPOE)
- Patient electronic access to health information
- Coordination of care through patient engagement
- Health information exchange (HIE)
- Public health and clinical data registry reporting

Discrete data collection and reporting within a health care organization is often cited as a key reason to implement health IT. Reporting supports analysis of workflows; guides efforts at utilization, scheduling, and resource management improvements; permits the measurement of costs, quality, and clinical outcomes; satisfies compliance regulations; serves research studies; and may be required by external public and private agencies. Important data will often reside across multiple systems, leading to the rise of the Data Warehouse, a central repository of integrated data, pooled from one or more separate sources.

Although local reporting has great potential, these local data are leading to the creation of national and international large databases, termed *data registries*.[9] Several observational data registries are focused on the fields of anesthesia and perioperative care: the Anesthesia Quality Institute (AQI), National Anesthesia Clinical Outcomes Registry (NACOR), the data registry of the Multicenter Perioperative Outcomes Group (MPOG), the Society for Ambulatory Anesthesia (SAMBA) database (SAMBA Outcomes Registry, SCOR), the Pediatric Regional Anesthesia Network, and the Society for Cardiovascular Anesthesiologists Adult Cardiac Anesthesia Module. These data registries can receive data directly from health IT, but several issues make sharing data from local health IT difficult. First, a significant investment of time and other resources is required to map local clinical concepts to the registry data schema. Another barrier to full harvesting of the information contained within these datasets is the inconsistency among the varieties of clinical taxonomies—a universally agreed-upon anesthesia "data dictionary" has yet to appear. A third issue is the missing or inaccurate data in health IT anesthesia documentation. This problem may be intractable without significant expense of resources or technological advances, because clinicians cannot be expected to be high-quality data-entry personnel while simultaneously administering anesthesia and caring for patients. Finally, much of health IT data is not discrete, structured, or categorized and rather is represented in plain text; that is, natural/human language. Until natural language processing (NLP, a field of artificial intelligence in which computer software understands human languages) matures, much of this information cannot be used to great extent.

Despite such challenges, there is significant potential for local and national registries with respect to quality improvement and health care research. These data can help describe the current state of clinical care and allow for benchmarking of process and outcome measures across multiple organizations, as well as sharing of lessons learned. Pooled data can also be analyzed to explore the relationships between specific patient care factors and clinical outcomes, especially when these outcomes are rare, although there are concerns that such observational, large cohort studies have significant shortcomings compared to traditional prospective randomized controlled trials.[10] But large datasets—often called *big data*—have helped big business in other fields visualize novel customer-product interrelationships and devise new strategies. Perhaps, big data techniques will be a cost- and time-effective way to augment prospective interventional studies and basic science research in anesthesia. Some anticipated uses of big data include modeling the risk of complications for perioperative patients and sending such information back to the EHR systems to inform clinical decision support (CDS) rules, possibly predicting problems before they actually occur. New computer techniques, such as machine learning or cognitive inference computing, may be able to use big data to draw conclusions from data in ways humans cannot.

PROFESSIONAL PERFORMANCE DATA REPORTING WITH HEALTH IT

Electronic reporting of professional quality is a specific use of health IT data that is responsible for many reporting initiatives. The Physician Quality Reporting System (PQRS) receives quality information from individual eligible professionals and group practices for CMS. PQRS quality measures are designed to help eligible professionals and group practices assess their performance across a range of quality domains. In 2019, CMS plans to merge several current quality and value-based assessment systems (including MU and PQRS) into either Merit-based Incentive Payment Systems (MIPS) or advanced Alternative Payment Models (APMs) stemming from the recent Medicare Access and CHIP Reauthorization Act of 2015 (MACRA).[11]

Quality measure reporting is recognized as a critical feature of an EHR. Some systems give the option of recording quality documentation within the EHR itself. Conversely, perhaps this reporting should be conducted outside the EHR to reduce the risk of unwanted legal discovery. An alternative to direct documentation is membership in a CMS-approved *qualified clinical data registry* that has an option for collection and submission of PQRS quality measures data on behalf of individual providers. The AQI is currently designated as both a Patient Safety Organization, which meets criteria established in the Patient Safety Rule of the HHS and a qualified clinical data registry. Qualified clinical data registries and patient safety organizations have a high level of medicolegal discovery protection to encourage accurate reporting.[12] Because MPOG is also a 2015 qualified clinical data registry via its Anesthesiology Performance Improvement and Reporting Exchange registry (ASPIRE), NACOR and MPOG participants can leverage their participation in these data registries to also satisfy federal reporting requirements.

FEATURES OF THE ELECTRONIC HEALTH RECORD IN ANESTHESIA AND PERIOPERATIVE CARE

The EHR is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Although there are significant realized and potential advantages of using EHRs for patients, providers, and the health care organization (Box 3.2), there are also many potential pitfalls. Careful design may make the difference between an effective EHR and a failed project. Because the fundamental purpose of the EHR is to support required clinical and administrative activities, the EHR should be intuitive and guide users as well as provide access to the right information at the right time to meet the needs of modern health care.

System feature requirements specific to AIMS include the AARK core functions (permanent recording of device data/device integration from hemodynamic monitors, anesthesia machines, and other clinical devices), capture of meta-data such as case events (e.g., in-the-room time; cardiopulmonary bypass time), documentation of preoperative evaluation (including the use of structured data to support reporting and CDS), management of perioperative orders, and integration with the patient's EHR and other records in various health IT systems. Key targets for integration include the following:

1. Medication data (requiring integration with pharmacy systems, which encompasses patient allergies, medication orders, administrations, interactions, formulary, and costs)
2. Laboratory and radiology systems (study orders and results, ability to record point-of-care test results)
3. Provider orders, notes, and consults
4. Nursing assessments including "ins and outs"
5. Billing functions (create charges to patient and their insurance plan)
6. Patient tracking (integration with admission/discharge/transfer application)
7. Perioperative management systems (e.g., case ordering, scheduling, utilization management)

For modular AIMS (components of a larger EHR), this integration may be operationalized via shared databases and routines (e.g., the AIMS module records medication orders and administrations in the enterprise database shared with the pharmacy and other clinical applications). For standalone AIMS, multiple interfaces (hardware and software) may be required to communicate data back and forth between the AIMS and the other health IT systems (described earlier) to avoid a perioperative information "black hole."

Perhaps the most important EHR feature is reliability. The EHR must be *fault tolerant*, meaning resistant to diverse challenges such as software "bugs," hacking, hardware failures, network errors, and even natural disasters. Preparing for *business continuity* after a failure includes a fail-safe workflow (e.g., paper records with scanning) and redundant data storage. Two common models for protecting data are (1) *data mirroring*, in which an application on a local workstation works with locally stored data that are automatically copied to remote storage (or a *cloud*), and (2) the *client-server* model in which the local workstation (the *client*) works with data stored on a remote computer (the *server*). An advantage of data mirroring is that it may be resistant to brief network interruptions. Client-server architectures can simplify system management by centralizing software and data to ease maintenance and backup activities. Box 3.3 shows features that should be available in the EHR.

Box 3.2 Potential Benefits of Health Information Technology (Health IT)

- It provides legible documentation.
- Information is accessible anywhere inside or outside facility; accessible via mobile technology; accessible by patients and providers.
- Data entry is traceable (an audit trail).
- It offers better completeness and accuracy of information.
- Information is current, and data repository has the same information no matter how it is accessed.
- It decreases paperwork.
- It may improve care quality, reduce errors, improve coordination of care.
- It increases clinical efficiency, if constructed properly.
- It may eventually reduce overall health care costs.
- It facilitates research.
- It can facilitate teaching and learning.
- Automates many processes. Can apply rules and logic to 100% of documentation sessions. It never sleeps.
- It offers administrative efficiencies—including improving charge capture.
- Can provide real-time alerts, prompts, notifications, reminders.
- Patients can access their own health information.
- Health IT vendor is certified by CHPL and supports provider and organization attestation for Meaningful Use.

CHPL, Certified health IT product list.

HEALTH CARE INFORMATION PRIVACY AND SECURITY

Health care providers are morally and legally obligated to protect the privacy of their patients as well as the security of the EHR. The Health Insurance Portability and Accountability Act (HIPAA) Privacy, Security, and Breach Notification Rules are U.S. regulations that codify this obligation into law.[13] The Privacy Rule sets standards for when and how protected health information (PHI), may be used and disclosed in any medium, including

Box 3.3 Some Desired Features and Capabilities in Health Information Technology

- Electronic document management
- Scanned document management
- Orders capability (computerized physician order entry, CPOE)
- Physiologic device data importation into EHR
- Exchanging information with other hospital processes and services: admission-discharge-transfer, scheduling, radiology, pharmacy, respiratory therapy, laboratory, blood bank, picture archiving and communication systems (PACS), emergency services
- Integration or communication with rehabilitation and long-term care facilities
- Staffing, concurrency checks
- Procedural documentation
- Templates that channel documentation, ensuring compliance with local organizational, national professional, and government guidelines, practice parameters, standards or requirements.
- Clinical decision-support checklists, alerts, reminders, emergency checklists and protocols
- "Scripting" or "macro" documentation allowing set-up and multi-item documentation for repetitive situations
- Structured handoffs
- Medication management
- Administrative reporting
- Mobile integration
- Charge capture
- Telemedicine
- Facility and professional charge capture and compliance checks and reports
- Patient communication and engagement (patient portals, care instructions, pathway guides, others)
- Structured discrete data (flowsheets, lists, checkboxes, buttons, etc.)
  - Categorized data, rather than free text
  - Facilitates reporting and data analysis
- Quality and outcomes analysis
  - Predictive modeling/analytics
  - Ability to export for data registries, population health projects
  - Data warehouse
  - Patient satisfaction surveys: HCAHAPS, Press-Ganey, others
  - Practice management reports

HCAHAPS, Hospital Consumer Assessment of Healthcare Providers and Systems survey; *CDS,* clinical decision support.

electronic, written, and oral. PHI includes any data that could be used to identify a patient, and when stored in digital form is termed electronic PHI (ePHI) (Box 3.4). The Security Rule requires certain precautions so that access to health IT systems is limited to those with legitimate purposes and proper authorization. The Breach Notification Rule requires health care providers and organizations to report any breach (a loss of patient privacy or failure of health IT security) to HHS, patients, and, in some cases, the media.

Box 3.4 Protected Health Information

- Names
- Geographic subdivisions smaller than a state
- All elements of dates and the age of patients older than 89 years old
- Telephone and facsimile numbers, email or IP addresses, URLs
- Social security numbers, medical record numbers, health plan numbers, account numbers
- Device identifiers and serial numbers
- Biometric identifiers (e.g., fingerprints, voiceprints)
- Photographs of the face or other identifying objects, tattoos
- Any other unique identifying number, characteristic, or code

IP, Internet protocol; *URLs,* uniform resource locators.

The HHS Office for Civil Rights is responsible for administering and enforcing the HIPAA Security Rule. The details are complex and are described in detail on the HHS website.[14] In addition to HIPAA, other applicable federal, state, and local laws, as well as health care organizations' policies, may govern the protection of ePHI. Some key HIPAA provisions include the provision of an official notice of privacy rights to all patients, generally at "check-in" or on admission. Therefore, routine use of clinical data for anesthesia care generally does not require additional consent. However, patient authorization may be required for disclosure of PHI to other entities. Patients have a right to their own medical record as well as to limit access to their PHI. There are also laws that restrict changing information in the electronic record for fraudulent purposes. Modern EHRs should have extensive audit trails and integrity checks to detect alterations.

Data security is an evolving field, and as new system capabilities offer increased features, new vulnerabilities also emerge. HHS has raised the alarm about a recent increase in ePHI privacy breaches, detailed in a document on privacy and the security of ePHI produced by ONC.[15] Institutions and individual providers share responsibility in breach prevention. The security of health IT is a significant concern; for example, unknown hospital system hackers have held EHR data for ransom. Recommended ePHI privacy and security practices for individuals are summarized in Box 3.5.

At the health care organizational level, the security officer must perform a risk analysis, develop a risk mitigation plan, and approve electronic systems, such as an EHR. Purchasers of health IT must conduct security risk analyses upon installation or upgrade. The health care organization may also benefit from the work of the Health Information Trust Alliance (HITRUST), a U.S. organization that, in collaboration with health care, technology, and information security leaders, has established a Common Security Framework. This includes a prescriptive set

of controls that seek to harmonize the requirements of multiple regulations and standards and can be employed by organizations that create, access, store, or exchange sensitive and regulated data. MU Stage 3 includes provisions that the Food and Drug Administration will deliver new tools to help mobile health product developers manage health care data security. See Table 3.1 for the three main U.S. agencies involved in health IT oversight.

SELECTED KEY TOPICS FOR HEALTH IT

Interoperability

Health care data collection and management systems often consist of a core *application* (computer program) and separate modular applications or data sources (within the organization and outside the organization) that extend functionality. Some organizations take a predominantly *modular* approach and have many separate applications from multiple vendors in order to meet their complete health IT needs (e.g., the laboratory system, the orders system). When functions are largely centralized within the same general application, an organization may be said to have an *enterprise* system. The ability to communicate among the various modules and with outside applications and data sources is referred to as *interoperability*. With *high-level interoperability*, organizations can share data even when using different types or versions of health IT.[16,17] Interoperability can be operationalized at different levels: software applications (1) may share information with built-in functionality, (2) may share data from application to application using standardized formats (e.g., HL7) or *application programming interfaces* (APIs), or (3) may interface remotely via *health information exchanges* (HIEs), which are large data stores that aggregate data from various health care organizations. Interoperability replaces inefficient paper workflows and reduces duplicative testing and medication mistakes. Interoperability also fosters better preventive care and chronic disease management, as well as improving provider communication.

In order to meet MU rules, modular software applications must be able to exchange and use electronic health information without special effort on the part of the user. The ONC has devised an "interoperability road map" to guide current and future development of a learning health system.[18] Interoperability also includes multiple device integration in which data from physiologic monitors, anesthesia machines, ventilators, intravenous pumps, medication dispensers, and other electronic devices are automatically captured by the EHR. The Internet of Things (IOT) is the broader trend in interoperability, in which many electronic devices (from home appliances, to vehicles, to personal health devices) are becoming interconnected, with resultant rapid growth in functionality (as well as increased security risks). Although interoperability is a challenging and resource-intensive process, it is a key promising feature of future health IT.

Box 3.5 Recommended Privacy and Security Practices for EHR Users

- Do not share passwords under any circumstances.
- Use a "strong" password (minimum of six characters, mix in uppercase, numbers, and symbols) on all computing devices including smartphones.
- Log out of computer systems when not in use.
- Destroy all papers containing PHI in a shredder or locked disposal bin.
- Do not leave PHI in any form lying around (better yet, avoid printing PHI).
- Do not send PHI over an unsecured email system, in social media, or leave messages with PHI on voicemail.

EHR, Electronic health record; *PHI*, protected health information.

System Design, User Interface, and Usability

The innumerable pieces of medical data in an EHR include laboratory test and imaging results, demographic information, billing and compliance data, scheduling, materials management, pharmacy data, physiologic data, and provider clinical documentation. Clinical assessment of patients might require users to find information on multiple screens, at different levels within the same application, or among several applications. A "hunt and peck"

Table 3.1 Overview of Health Human Service Entities Applicable to EHR Oversight

Federal Office/Agency	Website	Health IT-Related Responsibilities
Centers for Medicare and Medicaid Services (CMS)	www.cms.gov	Oversees Meaningful Use Program
Office for Civil Rights (OCR)	www.hhs.gov/ocr	Responsible for and enforces HIPAA Privacy, Security, and Breach Notification Rules
Office of the National Coordinator for Health Information Technology	www.HealthIT.gov www.healthit.gov/playbook	Support for the adoption and promotion of EHRs and Health Information Exchange (HIE)

EHRs, Electronic health records; *HHS*, U.S. Department of Health and Human Services; *HIPAA*, Health Insurance Portability & Accountability Act of 1996.