

# 1

## The Scope of Modern Anesthetic Practice

KATE LESLIE, LARS I. ERIKSSON, JEANINE P. WIENER-KRONISH, NEAL H. COHEN, LEE A. FLEISHER, and MICHAEL A. GROPPER

### KEY POINTS

- The scope of modern anesthesia practice includes preoperative evaluation and preparation; intraoperative care; postoperative care including acute pain management; critical care, resuscitation, and retrieval; chronic pain management; and palliative care. Anesthesia plays a key role in health service delivery and has a significant impact on population health and the burden of disease.
- Global and national forces for change include changing patient populations, locations of care, workforce, costs, quality and safety initiatives, research capability, and the availability of data. These forces have major implications for the delivery of care, evaluation and organization of the anesthesia practice, and education and training of physician anesthesiologists.
- The volume of patients presenting for perioperative and obstetric care continues to grow. Increasingly more patients at extremes of age are requiring anesthesia services. Many of the patients are elderly and have significant comorbidities, including obesity and opioid use disorder. This has important implications for delivery of care and health system issues.
- Anesthesia care is shifting from the traditional surgical suite to other procedural areas, ambulatory sites, office-based facilities, and home environments. As anesthesia care expands, anesthesiologists must focus on maintaining the safety and quality of care in these diverse settings.
- Global and regional deficits in the availability of high-quality anesthesia care must be managed by improving the supply of both physician and non-physician anesthesia providers, by better use of technology, and by limiting demand through health promotion and disease prevention strategies.
- Internationally, the costs of health care continue to escalate; unfortunately the increased spending has not consistently translated into improved health outcomes. Health policy initiatives including alternative approaches to healthcare financing and payment systems are increasingly being implemented to encourage efficient and effective team-based anesthesia care.
- Anesthesiology was among the first medical specialties to focus on improving the safety of patient care. As anesthesia has become safer, attention has intensified on quality improvement, a process designed to improve patient experience and outcomes through systematic change and evaluation.
- Basic, translational, clinical, and implementation research is vital to continuous improvement in outcomes. Opportunities to optimize care are supported by the availability of large datasets generated using electronic health records as well as novel analytic techniques. These changes create new opportunities for anesthesiologists to collaborate with basic and translational scientists to better understand current practices and define better ways to deliver care. As always the provision of resources to support these research initiatives is a challenge.
- The scope of modern anesthetic practice is continually expanding and changing. The changes occurring in health care in the 21st century create opportunities for anesthesiologists to assume a broader role in clinical practice and health policy, providing exciting opportunities for the next generation of physicians in our specialty.

### Introduction

Anesthesia is fundamental to the overall practice of medicine worldwide. Hundreds of millions of patients receive anesthesia care each year in association with a wide range of medical, surgical, and obstetric procedures. In addition to direct delivery of anesthesia to patients undergoing a surgical procedure, the scope of anesthesia practice extends beyond the traditional surgical suite to include preoperative

evaluation and management of underlying clinical conditions (see [Chapter 31](#)); postoperative care including acute pain management (see [Chapter 81](#)); critical care, resuscitation, and retrieval (see [Chapter 67](#)); chronic pain management (see [Chapter 51](#)); and palliative care (see [Chapter 52](#)). Anesthesia therefore plays an essential role in health service delivery (see [Chapter 3](#)) and has a significant impact on global health and the burden of disease (see [Chapter 2](#)). The purpose of *Miller's Anesthesia* is to cover the full scope of

contemporary anesthesia practice, from fundamental principles to advanced subspecialty procedures.

Every edition of this textbook begins with comments about the novel diagnostic and therapeutic procedures that have been developed since the last edition and the increasing complexity of patients presenting for anesthesia and perioperative care, especially those at the extremes of life. Each edition also provides descriptions about advances in anesthesiology that have facilitated patient care, including improved understanding of the processes that underlie disease and injury, the increasing sophistication of the pharmacologic and technical resources available, and the improvements in systems designed to promote safety and quality in health care. The 9th edition is no exception: in the last decade the advances in anesthesia and surgical care, especially for patients receiving complex clinical care, have been truly remarkable.

None of these advances would have been possible without the commitment of anesthesiologists to leadership, teaching, and research. Evidence of their contributions can be found in every chapter of the book, extending from improved understanding of the mechanisms of anesthesia and the processes that regulate organ function and drive organ failure; through new technologies, drugs, and systems of care and education; to improved understanding and acknowledgement of the critical role patients and their families play in decision making about healthcare and end-of-life issues.

The future of anesthesiology is filled with opportunities and challenges. Global and national forces will drive evidence-based, cost-effective perioperative and obstetric care by multiprofessional and multidisciplinary teams. These changes will be supported by integrated electronic medical records and large databases and registries of healthcare outputs and outcomes. Increasingly, anesthesia care has expanded outside the operating room, into preoperative clinics, intervention suites, extended postanesthesia care units, and even into patients' homes. As is true for other medical specialties, anesthesiologists have adopted telehealth strategies to extend the care provided to patients and colleagues beyond face-to-face encounters. Technological advances have and will continue to facilitate less invasive interventions and improved anesthesia delivery and monitoring systems. As a result, seriously ill and injured patients and those at the extremes of age, often with associated comorbidities now have access to care previously not available to them. Care is also becoming more personalized, in large part because of the availability of genetic testing and an improved understanding of the unique needs of each patient based on disease severity and his or her probability of responding to specific treatment modalities. Partially as a result of these improvements in care, the costs of caring for an aging population with progressively sophisticated therapies challenge all nations. These forces will likely have a major effect on the scope of perioperative care in general and anesthesia services in particular. Therefore, anesthesiologists must be involved in health policy decisions about the distribution of resources and the need for high-quality evidence to guide practice. In the rest of this chapter we will deal with some of these forces in detail.

## Forces That Will Change Practice (Fig. 1.1)

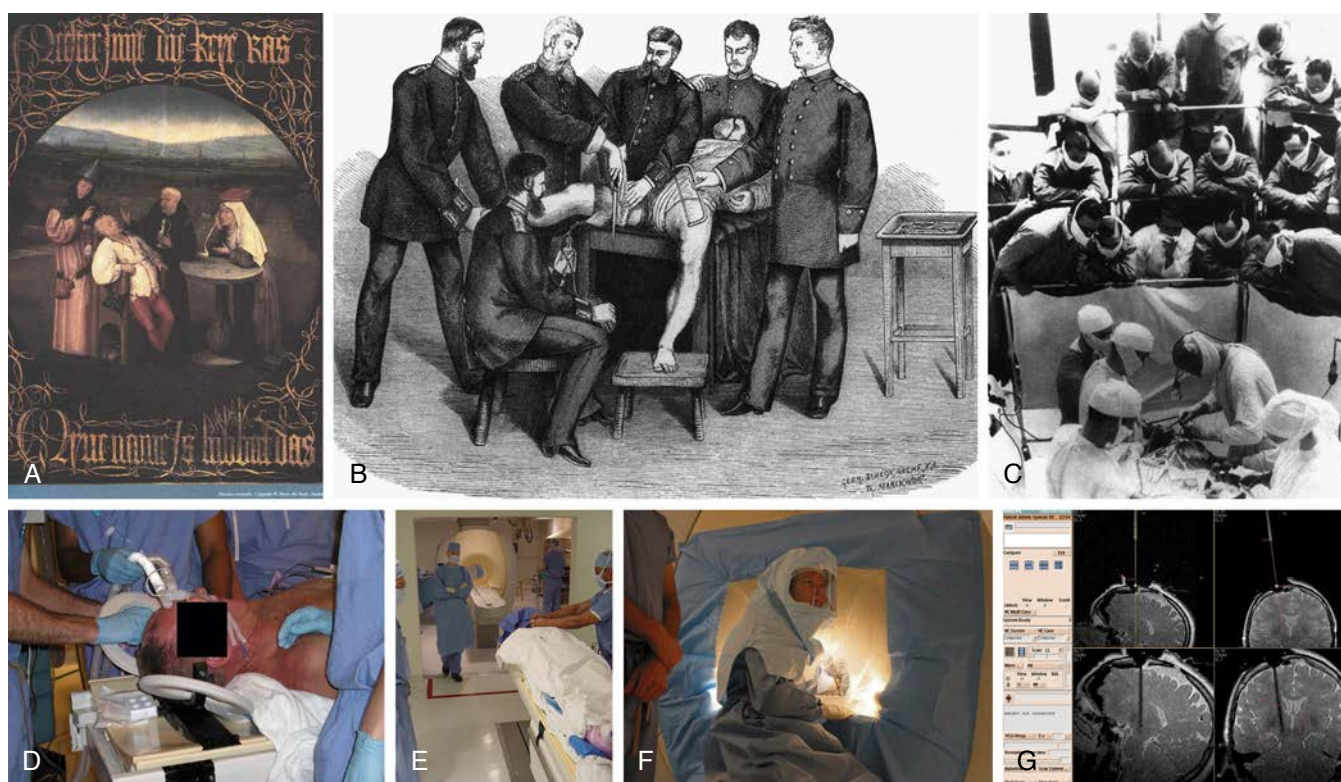
### CHANGING PATIENT POPULATIONS

The volume of patients having surgical procedures each year is large and growing. In 2012, more than 300 million patients had surgery worldwide.<sup>1</sup> This number probably underestimates the overall volume of patients requiring anesthesia services, in large part because much of anesthesia care is now provided outside of traditional surgical suite environments. Global initiatives aimed at delivering universal health coverage and safe and affordable surgery and anesthesia care will result in further increases in the number of patients requiring anesthesia care in coming decades (see [Chapter 2](#)).

Increasingly many of the patients requiring anesthesia services will be older and have multiple health problems, including obesity and chronic pain associated with opioid use.

The World Health Organization has estimated that by the year 2050 nearly one-quarter of the world's population will be over 60 years of age.<sup>2</sup> In the United States the number of people aged 65 years and over, and therefore eligible for treatment under Medicare, is expected to exceed 78 million by 2030. In high income countries the increase in the numbers of older patients will result from improved preventative care and management of chronic disease and injury. In low- and middle-income countries this change will result from improvements in maternal and child health and the eradication or control of infectious diseases. Concurrently, improvements in anesthetic and surgical care in many countries are increasing medical care options for older patients, who are now receiving more surgical services—many complicated procedures—than ever before. However, the accessibility of these additional options is presenting new challenges for both patients and providers. Aging is associated with a decline in physiologic reserve and organ function and an increase in the risk of disease, injury, and disability (both physical and cognitive). The aging process is highly variable, with significant influence from genetic, environmental, and societal factors. Aging is also associated with considerable changes in social and economic circumstances. Overall these factors lead the older adult to greater dependence on health and social care and challenges in the provision of safe surgery and anesthesia (see [Chapters 65 and 82](#)).

One significant public health issue that is accelerating internationally is obesity. It has emerged as a global health epidemic. In 2016, 39% of adults and 18% of children and adolescents worldwide were overweight.<sup>3</sup> In the United States the prevalence of overweight populations was 67.9% and 41.8% in adults and children, respectively. Although the rate of increase in the number of overweight and obese populations have slowed in some high-income nations, this is not the case in low- and middle-income countries. Poor access to healthy diets and limited exercise contribute to the problem. Obesity is associated with an increased burden of disease and injury, including diabetes and hypertension that result in the need for more interactions with the health system, high costs, and significant challenges in the provision of safe and high-quality surgical and anesthetic care (see [Chapter 58](#)).



**Fig. 1.1 Changing scope and settings of anesthesia and perioperative medicine.** (A) *The Cure of Folly*, by Hieronymus Bosch (c.1450–1516), depicting the removal of stones in the head, thought to be a cure for madness. (B) Friedrich Esmarch amputating with the use of anesthesia and antisepsis. (C) Harvey Cushing performing an operation. The Harvey Cushing Society is observing (1932). (D) Placement of a deep brain stimulator for the treatment of Parkinson disease using a real-time magnetic resonance (MR) imaging technology (MR fluoroscopy). The procedure occurs in the MR suite of the radiology department. The patient is anesthetized and (E) moved into the bore of the magnet. (F) A sterile field is created for intracranial instrumentation, and (G) electrodes are placed using real-time guidance. (A, Museo Nacional del Prado, Madrid. B, Woodcut from Esmarch's *Handbuch Der Kriegschirurgischen Technik* [1877]; Jeremy Norman & Co. C, Photograph by Richard Upjohn Light (Boston Medical Library). D to G, Courtesy Paul Larson, University of California–San Francisco, San Francisco Veterans Administration Medical Center.)

Pain management strategies have also had impact on anesthesia practice and perioperative care. The current opioid epidemic arose from increased prescription of opioid drugs to treat all types of acute and chronic pain, including postoperative pain. This crisis has been exacerbated by diversion of prescribed medication (i.e., diverting a medication from its original licit medical purpose) and use of “street” drugs, including opioids. The consequences are significant for individual patients and society as a whole. Opioid use has resulted in addiction, overdoses, homelessness, excessive emergency room visits, increased infections, and neonatal abstinence syndrome. The Centers for Disease Control and Prevention (CDC) estimated that more than 191 million prescriptions (58.7 prescriptions per 100 persons) were filled in the United States in 2017, with marked regional variation characterized with adverse physical, economic, and social circumstances.<sup>4</sup> Opioids were involved in 42,249 overdose deaths in 2016 (66.4% of all drug overdose deaths). The situation is similar in other nations, with the World Health Organization estimating that 27 million people worldwide suffered opioid use disorder in 2015.<sup>5</sup> Recent government action has been substantial, particularly in the United States. The Department of Health and Human Services has implemented a five-point plan to combat the crisis including: (1) improved access to prevention, treatment, and recovery support services; (2) targeted availability and distribution of overdose-reversing (narcotic antagonist)

drugs; (3) strengthened public health data reporting and collection; (4) support for cutting-edge research on addiction and pain; and (5) advances in pain management practice.<sup>6</sup> As experts in the pharmacology and clinical use of opioid drugs (see [Chapters 24, 51, and 81](#)), anesthesiologists and pain medicine specialists have and must continue their essential role in resolving this crisis.

## CHANGING LOCATIONS OF CARE

Anesthesia practice has expanded to a variety of locations. A number of factors account for this shift in anesthesia and perioperative care (see [Chapter 73](#)). The costs of traditional operating room care are high and the services available may be unnecessarily comprehensive and complex for the planned episode of care. With advances in clinical care, the need for inpatient perioperative care is reduced for many surgical procedures. As a result more and more procedures are being performed in hospital outpatient settings, ambulatory surgery centers, and office-based practices. The focus of accrediting bodies and anesthesiology societies has been on maintaining the safety and quality of anesthesia care in outpatient settings, including providing for extended admission and escalation of care when clinically necessary to ensure patient safety.<sup>7</sup> At the same time, the payment models have not necessarily kept pace with these advances in clinical care. In the United States, the growth in



nonhospital-based care has occurred despite curbs in reimbursement for ambulatory surgery by governmental and private payers.

The clinical practice for surgical patients has also changed because of changes in sites of care and inpatient management. For most patients, many aspects of perioperative care have shifted from the hospital or other healthcare facility to outpatient or home settings. As one example, the elimination of preoperative hospital admission to day-of-surgery admission is virtually complete in high-income nations. Hospital lengths of stay are also much shorter. As a result, postoperative care is increasingly undertaken in the home as well, often as part of enhanced recovery after surgery programs.<sup>8</sup> Advances in monitoring technology and pain management techniques create opportunities for anesthesiologists in which to not only participate, but also manage many aspects of postoperative care in the home. Although these changes have been beneficial to many patients with improved outcomes and reduced costs, for some families the transition to short hospital lengths of stay has created significant clinical and social problems. Anesthesiologists must have an understanding of patients perioperative and postoperative support needs and should be actively engaged in determining the most appropriate setting for a procedure and how to manage the transitions of care.<sup>9</sup>

In addition to the changes taking place for surgical patients, anesthesia care is also shifting outside the operating room as a result of the advances in minimally invasive techniques provided by cardiologists, radiologists, endoscopists, and pain medicine specialists (see [Chapters 51, 55, 57, and 73](#)). As the volume of these services increases, anesthesiologists may be asked to provide care in procedural areas that were not designed for delivery of anesthesia services, and often not properly equipped to support patient and provider needs. The locations are frequently remote from the operating suite and may lack the usual support available for the care of patients with complex cases and the management of crises. Anesthesiologists therefore must participate in planning for these services and provide leadership in defining and maintaining the same standards of operating room practice to other areas of the hospital.<sup>10,11</sup>

Another example of the advances in clinical care and implications is the remarkable increase in referrals for colonoscopy for colon cancer screening.<sup>12</sup> Although the sedation provider for colonoscopy widely varies internationally and regionally within the United States, anesthesiologists are now more commonly participating in the care of these patients, in part due to medical needs related to comorbidities, but also because of documented complications associated with the use of sedation that have resulted in airway compromise or respiratory failure. These complications have caused providers and payers to reevaluate patient needs, the appropriate training of practitioners delivering procedural sedation, and when to optimize care by having an anesthesia practitioner monitor the patient and administer sedation. American<sup>11,13</sup> and international<sup>14,15</sup> sedation guidelines recognize that for many patients, nonanesthesiologist physicians and independent or semi-independent nonmedical practitioners can provide deep sedation for endoscopy; however, all guidelines emphasize that anesthesiologists should be involved in the care of high-risk patients or those with significant comorbidities.

## CHANGES IN THE ANESTHESIA WORKFORCE

As a result of advances in perioperative care and the many other changes that impact the need for anesthesia practitioners, global and regional workforce shortages have been identified in recent years and are expected to increase (see [Chapter 2](#)). There are a number of reasons for these deficits including an insufficient number of medical graduates (in some places exacerbated by outward migration and an aging workforce), duty hour restrictions for practicing physicians (due to regulation of work hours, changing lifestyle preferences, and desire for better work-life balance), and increased demand for medical services (due to population growth and on a per capita basis). In addition to the impact of these societal changes, demand for physician care in the United States has increased in part due to the Patient Protection and Affordable Care Act (Affordable Care Act) with more patients having medical insurance and seeking care. To respond to the shortages, many countries within the Organisation for Economic Co-operation and Development (there are 36 member countries, including the United States) have increased medical school admissions in recent years.<sup>16</sup> Unfortunately, even this increase in number of trainees is insufficient to meet future needs. In 2017, the United States produced 7.55 medical graduates per 100,000 population, well below average (12 per 100,000 inhabitants). The Association of American Medical Colleges (AAMC) projects a shortage of up to 121,000 physicians by 2030.<sup>14</sup> At the same time, despite the increases in medical student enrollment, in the United States, most residency positions are funded by the Medicare program. As the medical school intakes have increased, this federal funding for residency positions (including anesthesiology) has not kept pace resulting in a bottleneck in the training pipeline. Along with reconsidering the cap on federally-funded positions, the AAMC has proposed alternative ways to leverage the skills and experience of physicians to advance care with improved use of technology and more interdisciplinary, team-based care as potential solutions.

Team-based care (anesthesia care team model) is already common in anesthesia practice, particularly in the United States. In the United States, the number of physician and nonphysician anesthesia providers are approaching parity, with the number of nurse anesthetists and anesthesia assistants increasing more rapidly than the number of physician anesthesiologists. In 2017, the American Society of Anesthesiologists (ASA) released a statement on the anesthesia care team that enunciated its vision for physician-led teams where anesthesiologists have a particular role in governance, planning, and oversight of anesthesia care, advanced airway management, and resuscitation.<sup>17</sup> This oversight includes defining and monitoring sedation provided in non-operating room locations and other requirements for the credentialing of providers to optimize care of the patient who requires deep sedation. Similar team-based approaches to care associated with physician supervision are commonplace or emerging in other countries around the world.

The number of women in medical schools has increased to over 50% of the student cohort in many countries. At the same time, until recently, United States anesthesiology training programs have recruited a smaller proportion of

women (37%). In academic departments, few women have reached the rank of professor, or become department chairs, or been elected to leadership positions in representative anesthesia organizations.<sup>18</sup> Programs to improve recruitment and advancement of women in academic medicine and anesthesiology have gained traction in the last decade (e.g., Athena Scientific Women's Academic Network<sup>19</sup>). In addition, all academic programs are paying more attention to diversity in the workforce, particularly among women and underrepresented minorities. With the increased understanding of the inequities, programs can be developed to more effectively address the disparities and broaden the diversity of the anesthesia workforce. It is essential that the anesthesia workforce reflect the diversity of the patient population that is served.

## INCREASING COSTS OF CARE

The costs of health care continue to grow internationally, with health care consuming 8% of gross domestic product (GDP) on average in most countries, whereas in the United States the costs are as high as 18% of GDP.<sup>20</sup> Unfortunately the increased healthcare expenditures have not translated into improved health outcomes, particularly for Americans. Despite the Affordable Care Act, the United States continues to have a large uninsured or underinsured population, lapses in quality and safety of care inside and outside the hospital, and high rates of drug abuse, violence, and use of firearms.<sup>21</sup> The National Academy of Medicine concluded that healthcare funding in the United States needs to “reorient competition in the healthcare system around the value of services provided rather than the volume of services provided.” This transition from volume to value is creating many new challenges and opportunities for anesthesiologists. As the health system adopts practices that provide documented improved outcomes at reduced costs, anesthesiologists must both understand the implications of these changes in clinical practices and also take a leadership role in identifying opportunities to reengineer care if the specialty is to retain its leadership role in quality and safety (see [Chapter 3](#)).

Payment for physician services is being modified to better align health systems, providers, and payers with respect to delivery of high-quality, patient-centered care. Compensation for clinical care continues to have a fee-for-service component, particularly in the United States; however, more compensation is becoming incentive-based to encourage changes in practice that improve efficiency and effectiveness. In contrast to fee-for-service models (which reward inputs), pay-for-performance models reward medical care that is consistent with published evidence and that improves the processes of care (e.g., timely administration of perioperative antibiotics), output (e.g., meeting targets for urgent surgery), or outcome (e.g., fewer central-line associated blood stream infections) measures. In the United States, recent pay-for-performance programs have included the Premier Hospital Quality Incentive Demonstration program of the Centers for Medicare and Medicaid Services (2003–2009) and the national Hospital Value-Based Purchasing Program, adopted after the passage of the Affordable Care Act (2011). This initial attempt to modify anesthesia practice has had limited impact on outcomes,

possibly because financial incentives are too small, payment is delayed, and/or the costs associated with implementing the programs is greater.<sup>22</sup> Nonetheless, incentive-based pay-for-performance programs (which are widespread in other nations with high-cost healthcare systems) will continue to expand.<sup>23</sup>

In addition to paying for high-quality performance, in the United States and other high-income nations there has been increasing emphasis on not paying for poor outcomes of errors in care. For example, some payers withhold payment for “never” events (e.g., wrong-sided surgery, pressure ulcers, retained foreign objects, mismatched blood transfusion) unless they are present on admission to the hospital. This approach may be expanded to withhold payment associated with treatment of preventable complications. A number of anesthesia-specific activities have been identified that impact outcomes and, if these are not provided, the consequence could be either no payment or penalties. For example, monitoring and maintaining body temperature during surgery as promoted by the Surgical Care Improvement Project is but one example of an anesthesia metric that affects outcomes and costs of care.<sup>24</sup> At the same time, identification of some of the interventions or monitoring techniques that impact outcome is challenging. As a result, it is critically important for anesthesiologists to continue to evaluate practices and do additional research to both optimize care and reduce costs.

Other changes in payment for clinical care have and will continue to have significant impact on compensation for anesthesia services. Some payers are providing “bundled” payments to compensate providers for episodes of care. This approach to payment is an integral part of the reforms introduced under the Affordable Care Act, although some of the incentives may be redefined by subsequent legislation. The Bundled Payments for Care Improvement initiative introduced by the Centers for Medicare and Medicaid Services tested the ability of bundling payments as a method for improving quality and lowering costs. The program has been most successful for selected clinical services such as total joint arthroplasty for which participation by anesthesiologists through the continuum of care can be most significant.<sup>25</sup> The ASA has proposed the Perioperative Surgical Home as an anesthesiologist-managed structure to coordinate perioperative team-based care. This model of coordinated care throughout the perioperative period should be amenable to bundled payments or other new approaches to compensating providers.<sup>26</sup>

## INCREASING FOCUS ON SAFETY AND QUALITY

Anesthesiology was among the first medical specialties to focus on improving patient safety.<sup>27</sup> A number of initiatives have had major impact on outcomes of care, including improved monitoring techniques, airway management options, and new improved drugs. Anesthesiologists have been actively assessing clinical care through the use of incident reporting systems, morbidity and mortality conferences, and “near-miss” reports. Incident reporting, which was initiated in the United States more than 50 years ago, has documented a decline in anesthesia-related mortality to less than 1 per 1 million population.<sup>28</sup> In recent years national incident reporting programs have been initiated

by the Anesthesia Quality Institute (Anesthesia Incident Reporting System<sup>29</sup>) and the Society of Pediatric Anesthesia (Wake Up Safe<sup>30</sup>). In addition to helping identify areas in which to improve clinical care, these programs provide legal protection to practitioners under the Patient Safety and Quality Improvement Act (2005). A number of programs have developed based on the experiences identified through these reporting mechanisms. Recognition of the human factors associated with adverse events has spawned a national and international movement directed at improving situational awareness and team functioning through simulation training (see [Chapter 6](#)). More recently programs to encourage healthcare providers and consumers to speak up about traditional patient safety concerns (e.g., commencing a wrong-side procedure) and unsafe professional behaviors (e.g., bullying and sexual harassment) have been integrated into workplaces nationwide and internationally.<sup>31</sup>

Anesthesiologists also led the way in the development of practice standards and checklists to improve clinical care. In some cases, the implementation of checklists has become a requirement for accreditation. In the last decade anesthesiologists were pivotal in the development, implementation, and evaluation of the World Health Organization's Surgical Safety Checklist.<sup>32</sup> Although the uptake of the Checklist has been patchy and its effect on outcomes has been inconsistent, the Checklist is widely implemented in the United States and other countries (see [Chapter 2](#)) in the belief that it will enable effective communication and a culture of safety.<sup>33</sup>

As anesthesia has become more and more safe, our attention has increasingly been focused on quality improvement, a process designed to improve patient experience and outcomes through systematic change and evaluation. In the United States, the Anesthesia Quality Institute established the National Anesthesia Clinical Outcomes Registry to enable systematic collection of quality information for use in quality improvement processes both nationally and locally.<sup>34</sup> Recently greater emphasis has been placed on longer-term and patient-centered or patient-reported outcomes. Many of these outcome measures have been incorporated into quality improvement programs and publicly reported metrics.<sup>35</sup> Anesthesiologists have identified the importance of assessing outcomes beyond the immediate perioperative period. As anesthesiologists assume a greater role in overall periprocedural care and outcomes, they will undoubtedly continue to advance the safety and quality agenda in large part due to their longstanding history in safety and quality as well as their training and pivotal role in perioperative care.

## NEW OPPORTUNITIES AND CHALLENGES IN RESEARCH

Academic anesthesia departments are committed to advancing the scientific underpinning of anesthesiology. Basic, translational, clinical, and implementation research is vital to the continuous improvement in patient and health service outcomes (see [Chapter 89](#)). Fortunately, overall funding for biomedical and health services research in the United States more than doubled between 1994 and 2012. Although overall research funding has increased,

since 2004 the overall growth of NIH funding for medical research has declined by 1.8%.<sup>36</sup> Private sources of funding have been important to supplement government-sponsored research support. Industry support is valuable and has been critical to the research agenda for academic departments. It also creates both real and perceived conflicts of interest that can be difficult to manage. Over the past decade, there has been a decline in early-stage research in favor of device development and clinical trials, poor mapping of research effort to the global burden of disease, and limited funding for critically important health services research.<sup>36</sup>

The implications of these changes in research support on anesthesia are significant. Academic anesthesia departments in the United States, as well as many other countries, continue to compete for government funding. Most benchmarks suggest that the specialty of anesthesiology in the United States fares poorly in National Institutes of Health funding when compared with other disciplines.<sup>37</sup> As a result, anesthesia departments, particularly in the United States have had to identify other funding sources, including foundations, industry, and philanthropy, particularly for early-career investigators.<sup>38</sup> For example the Foundation for Anesthesia Education and Research (FAER) has awarded more than \$40 million in grants since 1986 and has demonstrated the leverage that these grants provide in achieving federal funding (\$17 in funding for every \$1 investment). Similar programs are funded by the International Anesthesia Research Society and by other anesthesiology organizations and foundations worldwide. At the same time, and in many respects related to the funding challenges and competing clinical needs, research support and peer-reviewed publications, which have increased in other countries, have not kept pace in the United States. As a result, an increasing number of publications in peer-reviewed journals are from authors outside the United States.

Other factors have impact on what resources are available for research. The clinical demands put on the faculty in academic departments make it difficult for clinician scientists to pursue research activities. Associated with the increasing clinical volume, supervised residents cannot provide all of the clinical care without compromising their educational experiences and fulfilling duty hour and other requirements. As a result, the faculty members are delivering a larger percentage of care on their own. At the same time, the complexity of some of the basic and translational research requires significant dedicated time and skills that are difficult to maintain when the investigator is also encumbered with a high clinical demand. Historically, clinically generated income was used to support research in general and young investigators in particular. As labor and other costs increase (including those associated with quality of care initiatives, clinical and research compliance, and other activities), fewer funds are available to support research. As a result of the high cost of developing new drugs with insufficient incentives for the pharmaceutical industry to develop new anesthetic agents, there is a reduced pipeline of anesthesia drugs.<sup>39</sup>

Despite these challenges, basic science, as well as clinical and translational research, is being performed by anesthesiologists and advances in the specialty are taking place. New models for research have contributed to advances in



our understanding of basic concepts of anesthesia care as well as clinical advances. As is true for clinical care, collaboration has always been vital in biomedical research. In recent years anesthesiology research has increasingly been conducted by multiprofessional, multidisciplinary teams including biostatisticians, health informaticians, and health economists. Translation from discovery to practice has been facilitated by partnerships among basic scientists, clinical scientists, and implementation scientists.<sup>40</sup> In addition to collaborations among colleagues within one institution, increasingly clinical trials are being conducted by large, multicenter networks because of the recognition that single-center studies take too long and cannot recruit enough patients to answer the really important questions in anesthesiology.<sup>41-44</sup> Research based on electronic medical records and databases also requires collaboration between institutions, clinicians, and database experts (see later).

One of the primary motivators to support the research agenda for anesthesiology is the need to define reliable and peer-reviewed data upon which to advance the specialty. Although the volume of anesthesiology information and its ease of access have increased exponentially in the last decade, particularly through social media, anesthesiologists are progressively challenged to find reliable information to guide their practice. In addition to the difficulty of assessing the quality of some of the information posted on various web sites, anesthesiology has also been plagued by high-profile cases of research misconduct, including fabrication, falsification, and misleading reporting of research findings.<sup>45</sup> This has damaged the reputation of anesthesiology research and, as a result of unreliable data upon which to make clinical decisions, put patients at risk. Each anesthesiologist must be diligent in selecting a source of information that takes into consideration the standards of peer review of the material and the financial relationships between the authors and publishers.<sup>46</sup>

## INCREASING AVAILABILITY OF DATA

One of the areas of opportunity with respect to better understanding our clinical practices and defining ways to improve care is the increasing amount of data that can inform us. The last decade has seen unprecedented growth in the volume and availability of healthcare data. Electronic health record (EHR) systems (see [Chapter 4](#)) facilitate complete data capture and integration from multiple sources, including surgical equipment, anesthesia delivery systems, and physiologic monitors. The EHR has greatly facilitated documentation of individual patient care and provided aggregate data for healthcare services and populations. Other sources of routinely-collected data include health service billing systems, government and insurance databases, disease registries, and public health reporting. In addition, data specifically collected for research and quality improvement is increasingly shared, including research databases and biobanks (including genetic databanks). Meta-data related to the use of electronic resources and social media is also available for interrogation. These data require new management and analysis techniques that are beyond the scope of the practicing anesthesiologist or researcher (see [Chapter 4](#)). Truly “big” data includes terabytes of information, is generated and analyzed at high speed, and includes data in a wide variety of formats and from a wide variety of sources.<sup>47</sup>

These large data sets are increasingly being used to answer important research questions, to develop evidence-based clinical guidelines, and to assess the safety and quality of anesthesia and perioperative care, within and across different clinical environments and regions. Although technologic resources are not replacing randomized clinical trials, the information gleaned from large databases can be used to address important questions about how to most effectively deliver cost-effective care. At the same time, it is important to acknowledge the limitations of large databases, which may have missing critical elements of care or outcomes, could misclassify data, or in some cases, lack verification.<sup>48</sup>

## Conclusions

The scope of modern anesthetic practice is continually changing and expanding. The forces for change include changes in our patient population, locations of care, workforce, costs, quality and safety initiatives, research, and the availability of data. This chapter emphasizes the implications for these forces on the specialty as well as the influence they have on the delivery of health care in general. The changes occurring in health care in the 21st century obviously have implications for the role of anesthesiology in both the practice and delivery of medicine overall, and provide exciting opportunities for the next generation of practitioners and leaders in our specialty.

## Acknowledgment

The editors and publisher recognize the contributions of Ronald D. Miller, who was a contributing author to this topic in previous editions of this work. It has served as the foundation for the current chapter.

 Complete references available online at [expertconsult.com](https://expertconsult.com).

## References

1. Weiser TG, et al. *Lancet*. 2015;385(suppl 2):S11.
2. World Health Organisation. World report on ageing and health. Geneva. <https://www.who.int/ageing/events/world-report-2015-launch/en/>. Accessed October 18 2018.
3. World Health Organisation. Fact sheet on overweight and obesity. <http://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight>. Accessed October 18 2018.
4. Centers for Disease Control and Prevention. U.S. opioid prescribing rate maps. Atlanta. <https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html>. Accessed October 18 2018.
5. World Health Organisation. Information sheet on opioid overdose. Geneva. [http://www.who.int/substance\\_abuse/information-sheet/en/](http://www.who.int/substance_abuse/information-sheet/en/). Accessed October 18 2018.
6. Department of Health and Human Services. Help, resources and information. National opioid crisis. Washington. <https://www.hhs.gov/opioids/>. Accessed October 18 2018.
7. American Society of Anesthesiologists. Guidelines for office-based anesthesia. Schaumburg. <https://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources-search>. Accessed October 18 2018.
8. Kehlet H. *Br J Anaesth*. 1997;78:606.
9. Fleisher LA, et al. *Arch Surg*. 2004;139:67.
10. American Society of Anesthesiologists. Statement on non-operating room anesthetizing locations. Schaumburg. <https://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources-search>. Accessed.

11. American Society of Anesthesiologists task force on moderate procedural sedation and analgesia. *Anesthesiology*. 2018;128:437.
12. National Cancer Institute. Colorectal cancer screening. Bethesda. [http://progressreport.cancer.gov/detection/colorectal\\_cancer](http://progressreport.cancer.gov/detection/colorectal_cancer). Accessed October 18 2018.
13. Quality Management and Departmental Administration Committee. Advisory on granting privileges for deep sedation to non-anesthesiologist physicians (amended October 25, 2017). Schaumburg. <http://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources>. Accessed March 5 2018.
14. The Academy of Medical Royal Colleges. Safe sedation practice for healthcare procedures. London. <https://www.rcoa.ac.uk/system/files/PUB-SafeSedPrac2013.pdf>. Accessed March 5 2018.
15. Hinkelbein J, et al. *Eur J Anaesthesiol*. 2017;35:6.
16. Organisation for Economic Co-operation and Development. Medical graduates. Paris. <https://data.oecd.org/healthres/medical-graduates.htm>. Accessed October 18 2018.
17. American Society of Anesthesiologists. Statement on the anesthesia care team. Schaumburg. <http://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources/statement-on-anesthesia-care-team>. Accessed October 18 2018.
18. Leslie K, et al. *Anesth Analg*. 2017;124:1394.
19. Equality Challenge Unit. Athena SWAN Charter. London. <https://www.ecu.ac.uk/equality-charters/athena-swan/>. Accessed October 18 2018.
20. Organisation for Economic Co-operation and Development. Health spending. Paris. <https://data.oecd.org/healthres/health-spending.htm>. Accessed October 18 2018.
21. National Research Council and Institute of Medicine. U.S. *Health in International Perspective: shorter Lives, Poorer Health*. Washington: National Academies Press. 2013.
22. Bonfrer I, et al. *BMJ*. 2018;360:j5622.
23. European Observatory on Health Systems and Policies. Paying for performance in healthcare. Implications for health system performance and accountability. Maidenhead. [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0020/271073/Paying-for-Performance-in-Health-Care.pdf](http://www.euro.who.int/__data/assets/pdf_file/0020/271073/Paying-for-Performance-in-Health-Care.pdf). Accessed October 18 2018.
24. Scott AV, et al. *Anesthesiology*. 2015;123:116.
25. Centers for Medicare & Medicaid Services. Bundled Payments for Care Improvement (BPCI) Initiative: General Information. Washington DC. <https://innovation.cms.gov/initiatives/bundled-payments/>. Accessed October 18 2018.
26. American Society of Anesthesiologists. Perioperative surgical home. Schaumburg. <https://www.asahq.org/psh>. Accessed October 18 2018.
27. Kohn L, Corrigan J, Donaldson M. *To Err Is Human: Building a Safer Health System*. Washington DC: National Academy Press; 1999.
28. Li G, et al. *Anesthesiology*. 2009;110:759.
29. Anesthesia Quality Institute. Anesthesia incident reporting system (AIRS). Schaumburg. <https://qualityportal.aqihq.org/AIRSMain/AIRSSelectType/0>. Accessed October 18 2018.
30. Society for Pediatric Anesthesia. Wake up safe. Richmond. <http://www.wakeupsafe.org/>. Accessed October 18 2018.
31. Webb LE, et al. *Jt Comm J Qual Patient Saf*. 2016;42:149.
32. Haynes A, et al. *N Engl J Med*. 2009;360:491.
33. de Jager E, et al. *World J Surg*. 2016;40:1842.
34. Liao A, et al. *Anesth Analg*. 2015;121:1604.
35. Peden CJ, et al. *Br J Anaesth*. 2017;119:i5.
36. Moses H 3rd, et al. *JAMA*. 2015;313:174.
37. Reves JG. *Anesthesiology*. 2007;106:826.
38. Speck RM, et al. *Anesth Analg*. 2018;126:2116.
39. Vlassakov KV, Kissin I. *Trends Pharmacol Sci*. 2016;37:344.
40. Kharasch ED. *Anesthesiology*. 2018;128:693.
41. Myles P, et al. *BMJ Open*. 2017;7:e015358.
42. Pearse RM, et al. *JAMA*. 2014;311:2181.
43. Wijeyesundera DN, et al. *Lancet*. 2018;391:2631.
44. Devereaux P, et al. *N Engl J Med*. 2014;370:1494.
45. Moylan EC, Kowalczyk MK. *BMJ Open*. 2016;6:e012047.
46. Shen C, Bjork BC. *BMC Med*. 2015;13:230.
47. Levin MA, et al. *Anesth Analg*. 2015;121:1661.
48. Fleischut PM, et al. *Br J Anaesth*. 2013;111:532.



## References

1. Weiser TG, Haynes AB, Molina G, et al. Estimate of the global volume of surgery in 2012: an assessment supporting improved health outcomes. *Lancet*. 2015;385(suppl 2):S11.
2. World Health Organisation. World report on ageing and health. Geneva. <https://www.who.int/ageing/events/world-report-2015-launch/en/>. Accessed October 18 2018.
3. World Health Organisation. Fact sheet on overweight and obesity. <http://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight>. Accessed October 18 2018.
4. Centers for Disease Control and Prevention. U.S. opioid prescribing rate maps. Atlanta. <https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html>. Accessed October 18 2018.
5. World Health Organisation. Information sheet on opioid overdose. Geneva. [http://www.who.int/substance\\_abuse/information-sheet/en/](http://www.who.int/substance_abuse/information-sheet/en/). Accessed October 18 2018.
6. Department of Health and Human Services. Help, resources and information. National opioid crisis. Washington. <https://www.hhs.gov/opioids/>. Accessed October 18 2018.
7. American Society of Anesthesiologists. Guidelines for office-based anesthesia. Schaumburg. <https://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources-search>. Accessed October 18 2018.
8. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth*. 1997;78:606–617.
9. Fleisher LA, Pasternak LR, Herbert R, Anderson GF. Inpatient hospital admission and death after outpatient surgery in elderly patients: importance of patient and system characteristics and location of care. *Arch Surg*. 2004;139:67–72.
10. American Society of Anesthesiologists. Statement on non-operating room anesthetizing locations. Schaumburg. <https://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources-search>. Accessed.
11. American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology. Practice guidelines for moderate procedural sedation and analgesia 2018. *Anesthesiology*. 2018;128:437–479.
12. National Cancer Institute. Colorectal cancer screening. Bethesda. [http://progressreport.cancer.gov/detection/colorectal\\_cancer](http://progressreport.cancer.gov/detection/colorectal_cancer). Accessed October 18 2018.
13. Quality Management and Departmental Administration Committee. Advisory on granting privileges for deep sedation to non-anesthesiologist physicians (amended October 25, 2017). Schaumburg. <http://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources>. Accessed March 5 2018.
14. The Academy of Medical Royal Colleges. Safe sedation practice for healthcare procedures. London. <https://www.rcoa.ac.uk/system/files/PUB-SafeSedPrac2013.pdf>. Accessed March 5 2018.
15. Hinkelbein J, Lamperti M, Akeson J, et al. European Society of Anaesthesiology and European Board of Anaesthesiology guidelines for procedural sedation and analgesia in adults. *Eur J Anaesthesiol*. 2017;35:6–24.
16. Organisation for Economic Co-operation and Development. Medical graduates. Paris. <https://data.oecd.org/healthres/medical-graduates.htm>. Accessed October 18 2018.
17. American Society of Anesthesiologists. Statement on the anesthesia care team. Schaumburg. <http://www.asahq.org/quality-and-practice-management/standards-guidelines-and-related-resources/statement-on-anesthesia-care-team>. Accessed October 18 2018.
18. Leslie K, Hopf HW, Houston P, O'Sullivan E. Women, minorities, and leadership in anesthesiology: Take the pledge. *Anesth Analg*. 2017;124:1394–1396.
19. Equality Challenge Unit. Athena SWAN Charter. London. <https://www.ecu.ac.uk/equality-charters/athena-swan/>. Accessed October 18 2018.
20. Organisation for Economic Co-operation and Development. Health spending. Paris. <https://data.oecd.org/healthres/health-spending.htm>. Accessed October 18 2018.
21. National Research Council and Institute of Medicine. U.S. health in international perspective: shorter lives, poorer health. Washington: National Academies Press; 2013.
22. Bonfrer I, Figueroa JF, Zheng J, Orav EJ, Jha AK. Impact of financial incentives on early and late adopters among us hospitals: Observational study. *BMJ*. 2018;360:j5622.
23. European Observatory on Health Systems and Policies. Paying for performance in healthcare. Implications for health system performance and accountability. Maidenhead. [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0020/271073/Paying-for-Performance-in-Health-Care.pdf](http://www.euro.who.int/__data/assets/pdf_file/0020/271073/Paying-for-Performance-in-Health-Care.pdf). Accessed October 18 2018.
24. Scott AV, Stonemetz JL, Wasey JO, et al. compliance with surgical care improvement project for body temperature management (SCIP Inf-10) is associated with improved clinical outcomes. *Anesthesiology*. 2015;123:116–125.
25. Centers for Medicare & Medicaid Services. Bundled Payments for Care Improvement (BPCI) Initiative: General Information. Washington DC. <https://innovation.cms.gov/initiatives/bundled-payments/>. Accessed October 18 2018.
26. American Society of Anesthesiologists. Perioperative surgical home. Schaumburg. <https://www.asahq.org/psh>. Accessed October 18 2018.
27. Kohn L, Corrigan J, Donaldson M. *To Err Is Human: Building a Safer Health System*. Washington DC: National Academy Press; 1999.
28. Li G, Warner M, Lang BH, Huang L, Sun LS. Epidemiology of anesthesia-related mortality in the United States, 1999–2005. *Anesthesiology*. 2009;110:759–765.
29. Anesthesia Quality Institute. Anesthesia incident reporting system (AIRS). Schaumburg. <https://qualityportal.aqihq.org/AIRSMain/AIRSSelectType/0>. Accessed October 18 2018.
30. Society for Pediatric Anesthesia. Wake up safe. Richmond. <http://www.wakeupsafe.org/>. Accessed October 18 2018
31. Webb LE, Dmochowski RR, Moore IN, et al. Using coworker observations to promote accountability for disrespectful and unsafe behaviors by physicians and advanced practice professionals. *Jt Comm J Qual Patient Saf*. 2016;42:149–164.
32. Haynes A, Weiser T, Berry W, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360:491–499.
33. de Jager E, McKenna C, Bartlett L, Gunnarsson R, Ho YH. Postoperative adverse events inconsistently improved by the World Health Organization Surgical Safety Checklist: a systematic literature review of 25 studies. *World J Surg*. 2016;40:1842–1858.
34. Liao A, Havidich JE, Onega T, Dutton RP. The National Anesthesia Clinical Outcomes Registry. *Anesth Analg*. 2015;121:1604–1610.
35. Peden CJ, Campbell M, Aggarwal G. Quality, safety, and outcomes in anaesthesia: what's to be done? An international perspective. *Br J Anaesth*. 2017;119:i5–i14.
36. Moses H 3rd, Matheson DH, Cairns-Smith S, George BP, Palisch C, Dorsey ER. The anatomy of medical research: US and international comparisons. *Jama*. 2015;313:174–189.
37. Reves JG. We are what we make: transforming research in anesthesiology: the 45th Rovenstine Lecture. *Anesthesiology*. 2007;106:826–835.
38. Speck RM, Ward DS, Fleisher LA. Academic anesthesiology career development: a mixed-methods evaluation of the role of Foundation for Anesthesiology Education and Research funding. *Anesth Analg*. 2018;126:2116–2122.
39. Vlassakov KV, Kissin I. Decline in the development of new anesthetics. *Trends Pharmacol Sci*. 2016;37:344–352.
40. Kharasch ED. The challenges of translation. *Anesthesiology*. 2018;128:693–696.
41. Myles P, Bellomo R, Corcoran T, et al. Restrictive versus liberal fluid therapy in major abdominal surgery (RELIEF): rationale and design for a multicentre randomised trial. *BMJ Open*. 2017;7:e015358.
42. Pearse RM, Harrison DA, MacDonald N, et al. Effect of a perioperative, cardiac output-guided hemodynamic therapy algorithm on outcomes following major gastrointestinal surgery: a randomized clinical trial and systematic review. *JAMA*. 2014;311:2181–2190.
43. Wijesundera DN, Pearse RM, Shulman MA, et al. Assessment of functional capacity before major non-cardiac surgery: an international, prospective cohort study. *Lancet*. 2018;391:2631–2640.

44. Devereaux P, Sessler D, Mrkoprada M, et al. Aspirin in patients having non-cardiac surgery. *N Engl J Med*. 2014;370:1494–1503.
45. Moylan EC, Kowalczyk MK. Why articles are retracted: a retrospective cross-sectional study of retraction notices at BioMed Central. *BMJ Open*. 2016;6:e012047.
46. Shen C, Bjork BC. Predatory' open access: a longitudinal study of article volumes and market characteristics. *BMC Med*. 2015;13:230.
47. Levin MA, Wanderer JP, Ehrenfeld JM. Data, big data, and metadata in anesthesiology. *Anesth Analg*. 2015;121:1661–1667.
48. Fleischut PM, Mazumdar M, Memtsoudis SG. Perioperative database research: possibilities and pitfalls. *Br J Anaesth*. 2013;111:532–534.