No Mischievous Witchcraft

Anesthesiology in 1967, Bicentennial Year of the College of Physicians and Surgeons

Lester C. Mark, M.D., Richard J. Kitz, M.D.,† Leonard Brand, M.D.‡*

The physical act of surgery interested him without troubling him, but he was not able so easily to resolve the moral and ethical questions raised when one person, even a doctor, presumes to cut into another human body and to remove parts of it. The effects of anaesthesia troubled him almost more than the effrontery of human surgery: to induce sleep is to cause the soul to leave the body. This is a serious thing, not to be lightly regarded or undertaken. The competence of the anaesthetist becomes then of more moment than that of the surgeon, for he who has the po er to make the soul leave the body for a time must have the power to cause it to return before death results from soul loss. He must be a skilled man, indeed, and a good man; his power puts in his way the temptation to mischievous witchcraft.—*Ishi in Two Worlds,* Theodora Kroeber (University of California Press, 1962, p. 178).

ANESTHESIOLOGY is the oldest of the healing arts (Genesis, 2: 21), antedating even thoracic (*ibid.*) and plastic (Genesis, 2: 22) surgery. Despite this venerable beginning, anesthesiology is little more than a century old, and the golden age of scientific anesthesiology measures but a scant few decades. In the modern operating room, the major physiologic upheavals implicit in surgical access to vital areas such as brain, heart, lungs and great vessels can be mitigated by the expert anesthesiologist, enabling the surgeon to accomplish his mission and still remain within safe margins of physiologic tolerance. Indeed, cooperation between surgeon and anesthesiologist has extended the surgical horizon almost without limit. In addition, the scope of activities of the anesthesiologist extends beyond the operating room to encompass cardiorespiratory problems, convulsant states, trauma or unconsciousness from any cause, disturbances of acid-base balance, fluid therapy, inhalational therapy and last but not least, alleviation of pain. He is a full professional colleague of the internist and the pediatrician as well as of the surgical specialist.

This, then, is anesthesiology—in 1967. Today's anesthesiologist, with his keen physiologic and pharmacologic insight, his sophisticated apparatus and the many anesthetic agents and techniques at his command, is a far cry from the rag-and-bottle anesthetist. Progress has been revolutionary, yet challenges remain. The prospects are bright, both because of and in spite of the fact that anesthesiologists are in short supply to administer anesthetics, to teach other physicians the art and science of anesthesia and to conduct research. At present the supply of clinical anesthesioligists in the United States meets only 40 per cent of the numbers needed. Even more critical is the shortage of research workers and educators in the field. To provide, let us say, ten academically oriented anesthesiologists for each of the 88 medical schools in this country would require a total of 880 such individuals. It has been estimated that there are at present approximately 150 anesthesiologists in the United States who possess adequate qualifications for teaching and research in this vital and critically important field.[1]

Since this is the 200th anniversary year of the College of Physicians and Surgeons of Columbia University, it is perhaps appropriate

Received from the Department of Anesthesiology, Columbia University, College of Physicians and Surgeons, New York City.
* Professor of Anesthesiology, Columbia University, College of Physicians and Surgeons.
† Associate Professor of Anesthesiology, Columbia University, College of Physicians and Surgeons.
‡ Associate Professor of Clinical Anesthesiology, Columbia University, College of Physicians and Surgeons.

now to recount the history of its Department of Anesthesiology, reflecting as it does the trend of developments in the field as a whole, including the efforts of all training centers to meet the crisis of numbers. Beginning with the appointment of one nurse anesthetist in 1911, the department was guided through a vital transition phase by Virginia Apgar and, under the leadership of Emanuel M. Papper, has become one of the major departments of anesthesiology in the world.

History

The first mention of anesthesia appears in the Annual Reports of the Presbyterian Hospital, 43rd volume, 1911: "In our surgical service the anesthetic for operating is now given by a trained anesthetist instead of by a member of the house staff, as was the custom in this and most hospitals for many years." Margaret Galt Boise, R.N., received a portion of her training in anesthesia at the Mayo Clinic; she was also taught by Thomas L. Bennett, a consultant in anesthesia and one of New York's first anesthesiologists. It is interesting to note that of 1,714 anesthetics administered in 1911 at Presbyterian Hospital, 1,713 were nitrous oxide and oxygen supplemented with ether; 1 spinal anesthetic was given. Miss Boise resigned in 1914 to accept a similar post at Johns Hopkins University, later organizing at that university one of the first schools for nurse anesthetists in the country.

Miss Anne Penland, appointed in 1914 to succeed Miss Boise, had the distinction during World War I of accompanying the Presbyterian Hospital's surgical team to France as the first nurse anesthetist in Flanders. To a doubting British surgical chief, she demonstrated that a trained nurse could anesthetize a wounded British Tommie. As a result she was commissioned to set up a training program for anesthetists, thus freeing physicians for more "urgent" duties on the front lines. After the war, Miss Penland returned to Presbyterian Hospital as its chief anesthetist. During the next 2 decades she built a staff of 22 nurse anesthetists and organized rudimentary teaching programs for medical students and house staff. But the rapid progress of surgery soon required of anesthesia a sophistication and degree of understanding which the nurse anesthetist was unable to furnish. It was apparent that skilled physicians would be required if surgical progress was to continue and the safety of the patient to be assured.

Hugh Auchincloss, Sr., Clinical Professor of Surgery at the College of Physicians and Surgeons, in 1936 suggested to Virginia Apgar, then a junior fellow in surgery, that she consider a career in anesthesiology. The picture of a young, important, dynamic, developing specialty requiring a fusion of technical skill and medical knowledge and representing a major contribution to the care of sick people was indeed appealing. She proceeded to spend the last 6 months of the year learning the rudiments of clinical anesthesia from Miss Penland. After a further 7 months in Ralph Waters' department at the University of Wisconsin she returned to New York to complete her training at Bellevue Hospital in the anesthesia service of New York University under E. A. Rovenstine.

Dr. Apgar was appointed Director of the Division of Anesthesiology at Columbia-Presbyterian Medical Center in 1938 and immediately set about, in her typical whirlwind fashion, to lay the foundations for the future department of anesthesiology. This was to be centered around a full time staff of physicians who, in addition to caring for sick patients, would also be responsible for teaching and research, thus fulfilling the basic tenets upon which a medical center is constructed.

Prominent anesthesiologists, including Thomas L. Bennett, T. D. Buchanan, Paul M. Wood, Gaston Labat, Henry S. Holland and others, had been appointed to the consultant staff since 1906. Their contributions were of a clinical nature. Trained anesthesiologists with proper motivation and credentials for academic work were scarce in 1939. Not until 1941 did Dr. Apgar succeed in making her first full time appointment, when Ellen B. Foote was added to the staff as assistant anesthesiologist. Although more staff appointments were made from time to time, George H. Humphreys, II, Chairman of the Department of Surgery, noted in the 1947 Annual Report, "In order to expand and develop this program for the purposes not only of securing

the benefits of modern anesthesia for patients, but also of supplying the almost desperate need for well-trained men which we are particularly well able to fill, it will be necessary to build up a highly competent, full-time staff."

Twenty-two nurse anesthetists under Miss Penland were employed by the hospital in 1938 to care for 9,672 operative cases. With Miss Penland's concurrence, Dr. Apgar elected to replace vacated nurse positions with resident anesthesiologists and in this manner gradually to retire the nurse anesthetist. The late Robert Gladstone, appointed in October, 1938, was the first resident in anesthesiology at the Medical Center. He was followed in December by Charles Stein. Because of the shortage of facilities for house staff, it was necessary to find private accommodations for these residents. The cost of about $100 per month was borne personally by Dr. Apgar. The staff continued to grow and in 1949 reached a level of 32 physicians, of whom 11 were attending anesthesiologists and 22 residents; 4 nurses remained.

Utilizing the preceptorship method, the graduate teaching program encompassed inhalational, intravenous and regional anesthetic techniques. Each second year resident received 6 months of training in basic sciences as applied to anesthesia, including courses in biochemistry, physiology, surgical anatomy and pharmacology. When the use of cyclopropane was restricted for several years following an explosion in 1940, it became necessary to arrange a sojourn for the residents to gain experience with this valuable anesthetic at either the Philadelphia General Hospital or Albany Hospital. Cyclopropane anesthesia was reinstituted in the Medical Center with appropriate safety precautions in 1943. A nerve block clinic was opened in 1945.

Dr. Apgar organized an undergraduate training program in anesthesia for third and fourth year students of the College of Physicians and Surgeons in 1938. Its form consisted principally of didactic lectures, coupled with practical experience in the operating rooms. In the first year of the new program approximately 300 minor anesthetics were administered by members of the fourth year class. A 3-month elective course in anesthesia, first offered to third year students in 1943, was selected by 7 students in that year.

Research was virtually nonexistent in those days. Heavy clinical and teaching duties, lack of training in the methods of fundamental investigation and inadequate laboratory facilities combined to prevent the small attending staff from effective prosecution of basic research. A few clinical problems were studied; the first paper published by the service was "Experience with Pontocaine Spinal Anesthesia" by Dr. Apgar, in 1939.[2] It was apparent, however, that continued progress toward a truly academic department demanded considerable strengthening in the areas of basic and applied research and in certain aspects of internal organization. Dr. Apgar considered her good friend Emanuel M. Papper, then Associate Professor of Anesthesiology at New York University, eminently suited to the task. Following graduation from the New York University School of Medicine in 1938, Dr. Papper had elected additional years of training in internal medicine with Elaine P. Ralli and in physiology with Homer W. Smith, prior to completing the residency training in anesthesiology at Bellevue Hospital under E. A. Rovenstine. With Dr. Apgar's strong support, he was appointed Attending Anesthesiologist, Professor and Executive Officer in the summer of 1949. Dr. Apgar subsequently directed her attention to the important work of developing a system of anesthetic management for obstetric labor and delivery.

Many problems faced Dr. Papper in his attempts to modernize the department and to provide it with an academic orientation. Good patient care demanded the acquisition of a competent staff, the arrangement of a system for preoperative evaluation by the anesthesiologist and the establishment of suitable recovery room facilities. The undergraduate and graduate teaching efforts required the enrichment of an expanded program of intensive clinical supervision, didactic lectures and appropriate basic science courses. It was imperative that the modest research program be substantially augmented.

With much personal effort, a genius for organization and the encouragement of Dean Willard Rappleye and Mr. John Parke, Execu-

tive Vice-President of the Presbyterian Hospital, progress was rapid. In the 1951 Annual Report of the Medical Center, Dr. Humphreys wrote, "Under the leadership of Professor Emanuel M. Papper, the Anesthesia Service reached this year a level and breadth of effectiveness which was considered sufficient by the Faculty and Medical Board to justify independent departmental status. A resolution to this effect was passed by the Trustees of the University and Hospital to become effective January 1, 1952." To the best of our knowledge, the department thus became the third of the 88 medical school sections of anesthesia in the United States to achieve the distinction of independent departmental status.

The *sine qua non* of successful organization is dynamic leadership of a capable staff. Accumulation of a large and relatively permanent anesthesia staff, properly motivated and talented in the three essential areas of clinical medicine, teaching and research, was a difficult task. Appointments to the attending staff in 1949 of Shih-hsun Ngai and M. Jack Frumin, and of Duncan A. Holaday, Edgar C. Hanks, Herman Schwartz, Vance Lauderdale, Jr., Herbert Rackow, B. Raymond Fink and Lester C. Mark in the next few years, formed the nucleus around which was to be built an extensive training program for anesthesiologists. In 1966 the professional staff numbered 67, including 29 attending anesthesiologists, 30 residents and 8 research fellows. The supporting staff included 26 research associates and technicians, 10 secretaries, a nurse in charge of equipment and 7 aides.

It is difficult to quantify the effectiveness of an academic organization. Two areas lend themselves to mensuration: the amount and significance of research work and the number and achievements of physicians trained.

Research Activities

The wide-ranging interests of members of the department have added 600 scientific papers, books and abstracts to the publication explosion since Dr. Papper's arrival in 1949. Major areas of endeavor are indicated below in semi-chronological order.

Pharmacokinetics of Intravenous Anesthetic Agents.[3-15] The first paper on the subject by present members of the department was published in 1949.[3] Subsequent studies of the physiologic disposition and metabolic fate of barbiturates, other hypnotics and narcotic-analgesics are still continuing. The long list of participants and collaborators in this project, a major research effort of Lester C. Mark and Leonard Brand, includes Drs. Papper, Mark, Brand, B. B. Brodie, J. J. Burns, Peter G. Dayton, Gabriel G. Nahas, Richard C. Britton, A. H. Conney and R. Kuntzman. The program has aided understanding of the dynamics of distribution in the body and ultimate fate of the drugs studied. This in turn has resulted in more intelligent clinical use and has afforded clues to the development of better intravenous anesthetic agents. Specific contributions include an appreciation of the role of body fat in limiting the duration of action of thiobarbiturates,[3, 5] recognition of the phenomenon of acute tolerance to thiopental,[4] the use of serial biopsy techniques to elucidate the dynamics of drug distribution in the body,[5] the demonstration of drug metabolism by human liver *in vivo* and *in vitro* [11] and the synthesis (by J. M. Perel) and study of deuterium substituted barbiturates.[12] The conception and development of thiohexital, the most rapidly metabolized barbiturate yet studied in man, represents a potential breakthrough in the development of new and better anesthetic barbiturates.[10]

Pharmacokinetics of Inhalational Anesthetic Agents.[15-21] These studies of the behavior of anesthetic gases and vapors in man were initiated in 1958 by Herbert Rackow, Ernest Salanitre and Robert M. Epstein. Precise measurement and critical analysis of the time course of uptake and elimination of anesthetic gases and vapors provided scientific basis for their clinical use, rendering clinical anesthesia both more rational and safer. In addition, experimental verification of the concept of intercompartmental diffusion of anesthetic agents was obtained.[21]

Central and Peripheral Vasomotor Mechanisms.[22-37] The studies of splanchnic and renal circulation, initiated in 1951 by Stanley E. Bradley of the Department of Medicine, David V. Habif of the Department of Surgery and Dr. Papper,[22] were continued by

Dr. Epstein,[23-27] including a collaboration with Henry L. Price of the University of Pennsylvania.[25-27] Dr. Nahas has been concerned with the roles of acidosis and the sympathoadrenal system in cardiovascular function and shock.[28-31] Vasomotor responses in the peripheral vascular bed were investigated in normal animals by M. Jack Frumin and Shih-hsun Ngai[32-34] and, after sympathectomy, by Shirley Markee.[35] These studies have contributed to an understanding of the alterations in peripheral circulation produced by anesthesia and operation, thus materially aiding the care of surgical patients. Most recently, Drs. Ngai and Markee have become involved with the effects of anesthetics on central control of circulation,[36, 37] while Charles E. Wolf and Jean Henley have been studying the effects of total sympathetic blockade in man.

Cardiac Arrhythmias.[38-48] One of us was co-discoverer (with B. B. Brodie) of the antiarrhythmic drug, procaine amide.[38] More recently, post-hypercapnic and epinephrine-induced arrhythmias have been investigated by Drs. Nahas, Epstein and Mark,[39, 40] and by Richard S. Matteo, Ronald L. Katz anad Dr. Papper, respectively.[41-44] Dr. Katz has continued to investigate the mechanism of production of cardiac arrhythmias and the actions of newer antiarrhythmic agents.[45-48]

Physiology of the Newborn.[49-58] Initiated by Dr. Apgar, the program of understanding the alterations in the newborn during the birth process and after the administration of anesthetic and sedative drugs has been unfolded and developed in large measure in this department since 1952. The basic physiology of respiration, circulation, metabolism and thermal regulation of the newborn was studied in animals and in man under the leadership of L. Stanley James in collaboration with Drs. Apgar, Duncan A. Holaday, Frank Moya, Sol M. Shnider, Mieczyslaw Finster, Paul J. Poppers and Karlis Adamsons, Jr. In 1953 Dr. Apgar devised an objective scoring system to evaluate the clinical status of the newborn at birth,[49] thus providing a useful guide to clinical management. This system, widely accepted throughout the world as the standard method of evaluation of the newborn, has had profound impact on the development of improved anesthetic practices in obstetrics. Other aspects of the program have had important implications for both the basic scientist and the clinician in this hitherto relatively neglected and poorly understood area. Dr. James received the Mead Johnson Award in 1965 for this work.

Neural Regulation of Respiration.[59-68] Fundamental studies of localization of the components of the respiratory center complex in the brain stem, conducted by Dr. Ngai in collaboration with S. C. Wang of the Department of Pharmacology since 1952, culminated in the development of the now-standard physiologic concept that respiratory rhythmicity is dependent upon periodic modulation of the pontile apneustic center.[59-64] The same team elucidated the mechanisms of respiratory depressant action of general anesthetics and narcotic drugs.[65-67] Modulation of respiratory drive by cerebral activity during wakefulness and the influence of general anesthesia on this control system were delineated by B. Raymond Fink.[68]

Pulmonary Physiology.[69-72] Body CO_2 stores and the effects of anesthesia and cardiac surgery, including heart-lung bypass, on lung function and the mechanics of breathing are special interests of Stuart F. Sullivan and Richard W. Patterson, partly in collaboration with James R. Malm and Fred O. Bowman, Jr. of the Department of Surgery and Herbert Weintraub. They showed that ventilation-perfusion inequalities and blood-gas exchange following open-heart repair of acquired valvular disease are not substantially altered despite the hemodynamic improvement accomplished.[71] They also demonstrated that heart-lung bypass, in the absence of pneumothorax or other complicating factors and with the lung maintained in a state of static inflation, had no significant effect on the mechanics of breathing or on shunting within the lung.[72] Using the "isolated lung" during cardiac bypass, they found that airway hypocapnia produces marked decrease in compliance and marked increase in airway resistance and the work of breathing. These studies are being aided by a Research Career Development Award to Dr. Sullivan from the National Heart Institute.

Acidosis During Anesthesia.[28-31, 50, 63, 73-76] Development of an understanding of disturbances in acid-base balance during anesthesia has been a subject of intense study in the department since 1952, in a program initiated by Dr. Holaday and continued by Dr. Nahas and their collaborators over the years. The problems of respiratory acidosis during anesthesia and metabolic acidosis during shock have been thoroughly investigated, their implications recognized and corrective measures instituted.[28-31] Other mechanisms were elucidated.[73-76] The program also contributed to the development of techniques for ready monitoring of acid-base balance; this has proven of value in the management of patients during heart-lung bypass.[50] Dr. Nahas is principally responsible for the introduction of the buffer tromethamine (THAM) into clinical medicine.[30] Dr. Mark and others joined him in exploring the usefulness of peritoneal dialysis with THAM in the treatment of barbiturate and salicylate poisonings and hypercapnic acidosis.[75, 76]

Chemistry, Physiology, and Pharmacology of Neuromuscular Transmission and Blockade.[77-90] Since 1962, this program has been a joint effort of Richard J. Kitz (in collaboration with Irwin B. Wilson of the Department of Biochemistry), Joannes H. Karis and Aaron J. Gissen (both in collaboration with William L. Nastuk of the Department of Physiology) and Ronald L. Katz. The program has clarified the mode of action of muscle relaxant drugs, antagonists and anesthetic agents on the myoneural junction. Dr. Katz has also developed a simple instrument to monitor the effects of muscle relaxants administered during clinical anesthesia, thus rendering their use safer and more rational.[89] These studies provided the nucleus for a Postgraduate Course titled "Advances in Anesthesiology: Muscle Relaxants," soon to be available in book form.[90]

Tissue Oxygen Consumption.[91-93] The metabolic effects of anesthetics on brain tissue have been under study by Drs. Matteo, George P. Hoech, Jr. and Fink,[91] while hyperbaric oxygenation and oxygen toxicity have been concerns of Drs. Matteo and Nahas.[92, 93]

Anesthetic Apparatus.[89, 94-101] Significant contributions to patient care have resulted from the development of numerous items of anesthetic equipment designed to effect safety as well as convenience. This has been made possible in large part through the design of special instruments by Arnold S. J. Lee in collaboration with various members of the department, including Drs. Rackow, Salanitre, Epstein and Frumin. Some examples are a "master-slave" regulating valve to prevent accidental failure of the oxygen supply during anesthesia,[94] superior nonrebreathing valves and controls for safe and easy administration of inhalational anesthetics, especially in infants,[95-98] and ventilators with important "fail-safe" features and simple control systems.[99, 100] A simple device for the continuous monitoring of arterial blood pressure was developed by Dr. Fink.[101] The apparatus for continuous monitoring of muscle relaxant effects was mentioned above.[89]

Sustained research effort requires appropriately equipped laboratories as well as trained investigators. Space for research was acutely limited in the early nineteen-fifties, when the department had only 1,000 square feet directly available for research purposes. Other scientists in major preclinical and clinical departments of the Medical Center generously opened their facilities to individual members of the anesthesia staff, thereby materially alleviating the shortage of space. A happy concomitant was the establishment of mutual respect and rapport between the basic scientist and the clinical investigator. The translation of basic knowledge and ideas into understandable formulae for patient care was thus expedited.

With the opening of the William Black Medical Research Building in 1965, the laboratories of the Department of Anesthesiology more than quadrupled in size. The use of space in other departmental and hospital areas continues in collaborative research with members of the Departments of Pharmacology, Physiology, Biochemistry, Neurology, Surgery, Obstetrics and Gynecology and Pediatrics.

It has long been recognized that the application of engineering methods and technology is essential to the solution of major problems in anesthesiology. To this end a consortium of the Departments of Anesthesiology, Sur-

gery, Pediatrics and Biochemistry established the Medical Instrumentation Laboratory of Columbia University in nearby Fort Lee, New Jersey. This modern air-conditioned unit measuring 8,000 square feet in area is a completely equipped facility for the design, fabrication and testing of instrumentation for sophisticated research and clinical care systems. The staff of 13, including an electronic engineer, an optical-mechanical engineer, a designer-draftsman, 3 instrument makers and suitable supporting personnel, is under the capable direction of Arnold S. J. Lee. The alliance of basic and clinical scientists with competent biomedical engineers has already materially aided progress in several areas of the departmental research program.

Education and Training

A prime function of a teaching department and of the specialty as a whole is the production of skilled anesthesiologists. The Department of Anesthesiology at the College of Physicians and Surgeons of Columbia University is meeting its self-imposed obligations in this area. With the roster of patients in the medical center requiring anesthetic care rising from 15,500 in 1950 to nearly 25,000 in 1966, ample clinical experience is available for graduate and undergraduate education in all areas of anesthetic management. The preceptoral method of instruction forms the lattice structure of the teaching program, while the large attending staff allows for the assignment of one or 2 residents to each preceptor. The 3-week clerkship in anesthesiology for third year medical students is an abbreviated version of the residency educational system.

A departmental credo is that superior patient care will result if the well-trained clinician has in addition an understanding of basic scientific research. To further this concept one or more years of research training after the clinical residency are available with outstanding basic scientists. The National Institutes of Health have supported this program since 1959.

Since the appointment of the first resident in 1938, the department has educated over 300 residents in anesthesiology. In addition, 40 fellows have undertaken added years of training in research. It is significant that over 40 per cent of the alumni assumed positions in academic medicine. Twenty-one have become full professors and 11 of these, chairmen of departments. Thirteen have achieved the rank of associate professor and 34, assistant professor.

Other Activities

Anesthesiologists should give freely of themselves as specialists, as physicians and as citizens, not only within their own institutions but also in the professional and lay communities beyond, on local, national and international levels. In all of these areas, members of the Department of Anesthesiology at Columbia University are exerting their influence, individually and collectively.

On the local scene, the medical community partakes of the educational opportunity provided by the Thursday Evening Lecture Series on anesthetic and related problems. Professionally, members of the department have headed, organized or participated in many medical and scientific committees, conferences, postgraduate courses and seminars. As citizens in the community (and incidentally reinforcing the "image" of anesthesiology), 2 are presidents of local school boards, one is a newly ordained deacon of his church, and others serve as committeemen in the Boy Scouts, charitable organizations and political parties.

Nationally, members of the department have been appointed to scientific committees and councils of both governmental and private agencies and as civilian consultants to the Armed Forces. Dr. Papper recently completed a 6-month assignment in Washington, D. C., as Special Consultant to the National Institute of General Medical Sciences, with the specific assignment of implementing support for research and clinical training programs in anesthesiology.

Internationally, the department has encouraged continual exchange of ideas and personnel in research. Many scientists from abroad have visited for periods of 3 to 12 months. In turn, staff members on sabbatical leave have engaged in research projects in Scandinavia, England and (soon) Japan. Overseas consultant services have been provided by several

to the World Health Organization in Denmark and in Puerto Rico.

l'Envoi

And so the department, under Dr. Papper's leadership, has come of age, paralleling progress in anesthesiology as a whole. Three decades ago the field was revolutionized, first for the patient, by world-wide acceptance of the intravenous route for induction of anesthesia, and soon afterwards for the surgeon, by the introduction of the muscle relaxant drugs. What lies in store for us at the turn of the century? In reasonable anticipation that the secrets of the cell, of life itself and consequently of anesthesia will by then be unlocked, anesthetic practice should be totally different from that of today. Our younger contemporaries may reasonably expect to participate in this splendid maturation. To the anesthesiologist-in-training of today belongs an auspicious future.

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