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RANDALL C. WETZEL, MB, BS, FAAP, FCCM  
GUEST EDITOR

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# THE PEDIATRIC CLINICS OF NORTH AMERICA

Pediatric Anesthesia

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FEBRUARY

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## Pediatric Anesthesia

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### **PEDIATRIC OPHTHALMOLOGY**

Leonard B. Nelson, MD, *Guest Editor*

## PREFACE



RANDALL C. WETZEL, MB, BS, FAAP, FCCM  
Guest Editor

As an avid reader of the *Pediatric Clinics*, I consider it a privilege to have guest edited the first issue devoted to anesthesiology. Over the last decade, pediatric anesthesiology has been dramatically transformed by the many anesthesiologists who have specialized in the care of children. In addition, pediatricians increasingly have entered anesthesiology and brought their skills and training to the perioperative care of children. The knowledge gained in neonatal intensive care units and pediatric intensive care units is now readily available for children undergoing surgery. Pediatric anesthesiology has become a mature specialty within anesthesiology as signalled by the formation of the Society for Pediatric Anesthesia (SPA) under the auspices of the American Society of Anesthesiologists (ASA) in 1987. Within the specialty of anesthesiology, there is now a dedicated group of physicians who identify with pediatricians in the other pediatric subspecialties.

Pediatrics and anesthesiology have long been closely allied. Intensive care units, now an integral part of pediatric care, originated from anesthesia recovery rooms and polio units run by anesthesiologists in the 1950s. Anesthesiologists, such as Dr. Apgar, Dr. Downes, and Dr. Gregory have made valuable contributions to the care of infants and children. In turn, the skill and knowledge of pediatricians have provided great insight into the management of children in the perioperative period. This rich cross-fertilization has made it possible for all children to receive state-of-the-art care whether in the operating room or intensive care unit, and whether being cared for by an anesthesiologist or pediatrician.

The perioperative and critical care of children is firmly seated in anesthesiology; nevertheless, it is increasingly recognized that it also has a proper home in pediatrics. The American Academy of Pediatrics (AAP) has had a subsection on Anesthesiology since 1966. In children's hospitals, anesthesiologists are involved in the intensive care units, resuscitation, transport, and pain management. Many pediatricians have followed their patients into the operating room by becoming pediatric anesthesiologists. Pediatric anesthesiology has been formed by the merging of contributions, physicians, and insights from both parent specialties.

As anesthesiology and pediatrics meet in the subspecialty of pediatric anesthesiology, occasional misunderstandings occur between practitioners of both specialties. Anesthesiologists in the past have failed to understand the distress of



parents and pediatricians when a child returns from the operating room having received significant intravascular volume replacement and multiple potent drugs. Pediatricians have occasionally misunderstood the priorities and requirements of life support and analgesia during surgery and anesthesia that are of utmost importance to the anesthesiologist. Much has been written by pediatric trained anesthesiologists to educate their anesthesia colleagues in how to provide better care for children. This issue hopes to continue this process by providing pediatricians with insights into the concerns of pediatric anesthesiologists.

The other purpose of this issue is to aid pediatricians who serve as a perioperative resource for the child and family. By better understanding the anesthesiologist's concerns and the perioperative prerequisites, the pediatrician can better prepare and inform the family. There is increasing pressure to decrease hospital contact in the perioperative period. Children undergoing routine procedures may commonly spend only a few brief hours in a hospital or surgicentre. Often the preoperative evaluation, the answering of the family's questions, and even some postoperative care, must be done by the practitioner with the closest family contact, namely the pediatrician. In addition, to provide perioperative consultation for children, the pediatrician should understand the perioperative anesthetic issues. This issue of the *Pediatric Clinics* addresses these issues and is intended to serve as a resource for the pediatrician.

To meet these purposes, many pediatric anesthesiologists from around the country have enthusiastically contributed to this issue of *Pediatric Clinics of North America*. I would like to thank each of my colleagues who have so generously given of their time and expertise to achieve a better understanding between pediatricians and anesthesiologists. It is our hope that this issue will serve to improve the perioperative care of children—the common goal that unites our specialties.

RANDALL C. WETZEL, MB, BS, FAAP, FCCM

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This article reviews the origins of anesthesia for infants and children, the past and current interdependence of pediatric general and cardiovascular surgery, neonatology and pediatric anesthesia, the contributions of pediatric anesthesiology to pediatric critical care medicine and pain management, and the important role modern pediatric anesthesiology plays in children's health care.

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Mark S. Schreiner

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Lynn D. Martin

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Former preterm infants represent a major operative risk. The incidence of apnea, periodic breathing, and bradycardia is higher among this population than among term infants. This article reviews special considerations if surgery cannot be deferred until the infant has mature respiratory control mechanisms.

### **The Night After Surgery: Postoperative Management of the Pediatric Outpatient—Surgical and Anesthetic Aspects**

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Myron Yaster, Juan E. Sola, Walter Pegoli, Jr, and Charles N. Paidas

Outpatient or “ambulatory” anesthesia and surgery has revolutionized the way surgery is practiced in the United States. Safe, reliable, inexpensive, and convenient outpatient surgery is an attractive option for parents, children, health care providers, and insurers.

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Malignant hyperthermia is a potentially life-threatening disorder provoked by exposure to drugs frequently used to provide general anesthesia. Morbidity and mortality have been dramatically

reduced by increased awareness and institution of early, effective treatment. Patients at risk can often be identified preoperatively enabling patient education, appropriate preparation of equipment, and use of an anesthetic technique that avoids precipitation of this syndrome.

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**Inside back cover**

# HISTORIC ORIGINS AND ROLE OF PEDIATRIC ANESTHESIOLOGY IN CHILD HEALTH CARE

John J. Downes, MD

The nightmare of torture for a child undergoing even the simplest operation prior to the use of general inhalational anesthesia seems incomprehensible today. Among the advances in medicine during the past 150 years, certainly the introduction of surgical anesthesia must rank with immunization, antibiotics, asepsis, and modern surgery as the profession's greatest gifts to humankind, especially to children.

This article reviews (1) the origins of anesthesia for infants and children, (2) the past and current interdependence of pediatric general and cardiovascular surgery, neonatology, and pediatric anesthesiology, (3) the contributions of pediatric anesthesiology to pediatric critical care medicine and pain management, and (4) the important role which modern pediatric anesthesiology plays in children's health care. To offer an historic perspective, this article is divided into chronologic categories, beginning with the first recorded general anesthetic administered to a child, emphasizing the early contributions which laid the foundation for the subspecialty, outlining the evolution of the new field through its rapid growth from 1960 to 1980, and concluding with the current relationship of this subspecialty to child health and its role in the future.

## 1842 TO 1945

### Initial Accomplishments

In early 1842, Crawford W. Long, MD, a graduate of the University of Pennsylvania School of Medicine and a rural practitioner in the village of Jeffer-

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From the Department of Anesthesiology and Critical Care Medicine, The Children's Hospital of Philadelphia; and Department of Anesthesia and Pediatrics, University of Pennsylvania, Philadelphia, Pennsylvania

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son, Georgia, conducted “ether frolics” for the social amusement of other young men. He noted that the occasional bruises encountered by himself and his colleagues caused no pain when they occurred during the “exhilarating” effects induced by inhalation of ether vapor from a saturated towel. The practice of inhaling nitrous oxide or “sulfuric ether” for their hallucinatory effects was not unusual at that time in the United States. Dr. Long surmised correctly that he might perform minor operative procedures painlessly while patients were in this state of apparent anesthesia.

On the evening of March 30, 1842, Dr. Long excised a cyst from the neck of a young man, James Venable. “The patient continued to inhale ether during the time of the operation; when informed it was over, seemed incredulous, until the tumor was shown to him.”<sup>34</sup> This event is the first recorded experience of surgical anesthesia, which preceded by more than 4 years the highly publicized demonstration of ether anesthesia by the dentist, W. T. G. Morton on October 16, 1846, at the Massachusetts General Hospital. The third patient, and the first child of which there is record, to benefit from general anesthesia is described by Dr. Long: “My third experiment in etherization was made on the 3rd July, 1842, and was on a Negro boy, the property of Mrs. S. Hemphill, who resides nine miles from Jefferson. The boy had a disease of the toe, which rendered its amputation necessary, and the operation was performed without the boy evincing the least sign of pain.”

Thus, the practice of pediatric anesthesia began in the hands of an observant rural Southern physician administering ether to a young victim of slavery. Dr. Long did not report his “experiments” until 1849, 3 years after Morton’s demonstration of ether’s efficacy had been confirmed widely in the United States and Europe, because of his desire to have a large series despite his small rural surgical practice. Nonetheless, Dr. Long’s primacy has been assured through published eyewitness accounts and testimonies as well as the scrutiny of historic scholars.

The father of the medical specialty of anesthesiology, John Snow, MD, of London, began providing anesthesia for adults and children aged 4 years through adolescence in 1847 with ether.<sup>47</sup> He soon switched, however, to the more potent, rapid-acting but cardiotoxic halogenated ether called *chloroform*. By 1857, he had anesthetized successfully by chloroform inhalation hundreds of children, including 186 under the age of 1 year. Additionally, through his keen observations and logical analysis, he concluded that in children “The effects of chloroform are more quickly produced and also subside more quickly than in adults, owing no doubt to quicker breathing and circulation.”<sup>46</sup> This statement would be proven correct more than a century later with sophisticated gas analyzers and measurements of ventilation and cardiac output in infants.<sup>11, 16, 42</sup>

During the ensuing century following Dr. Long’s first recorded general anesthetic in a child, thousands of infants and children underwent general anesthesia, including newborns, and survived. Yet in the hands of those less skilled than Dr. Snow, chloroform led to an unacceptably frequent incidence of extreme hypotension or cardiac arrest. Diethyl ether (popularly known as “ether”) proved by far to be the most effective and safe agent for widespread application, usually by the open drop method, until the invention and manufacture of reliable vaporizers and precision flowmeters for concomitant nitrous oxide and oxygen administration in the 1920s.

## Pediatric Surgery

Throughout the first three decades of this century, most physicians treated children as miniature adults. A stellar exception to this, and a major force leading

to the inevitable evolution of pediatric anesthesia, was William T. Ladd, MD, the father of pediatric surgery. From 1917 until his retirement in 1945, Dr. Ladd devoted his enormous talent as a clinician, teacher, and author to the surgical care of children at the Children's Hospital of Boston.<sup>44</sup> He and his successor as Surgeon-in-Chief at that hospital, Robert Gross, MD, trained most of the next generation of leading pediatric surgeons in North America, including C. Everett Koop, MD, who became the first full-time Surgeon-in-Chief at the Children's Hospital of Philadelphia following his training with Dr. Gross in 1946. These surgeons and their pediatric collaborators pushed back the darkness and hopelessness surrounding the diagnosis and treatment of many of the common congenital anomalies and other disorders afflicting the newborn as well as older children. This progress demanded ever-increasing anesthesia skills and vital system surveillance and support. Such demands inevitably led to the development of a clinical and an academic subspecialty concentrated on pediatric anesthesia.

### **Cardiovascular Surgery In Children**

Concomitant with the evolution of general pediatric surgery came the birth and early developments in cardiovascular surgery for children. The first repair of a congenital cardiovascular lesion, ligation of a patent ductus arteriosus in a 7-year-old girl, by Dr. Robert Gross at the Children's Hospital of Boston in 1939 inaugurated the curative approach to these disorders.<sup>24</sup> The year 1946 saw the successful repair of aortic coarctation in children independently by Dr. C. Craaford in Sweden and Dr. Gross in 1945,<sup>25</sup> and the invention of the Blalock-Taussig palliative procedure for tetralogy of Fallot at Johns Hopkins Hospital.<sup>8</sup> The need clearly arose for special anesthesia knowledge and skills as well as dedicated personnel and specific areas to care for postoperative pediatric cardiac patients. Drs. Merel Harmel and Austin Lamont<sup>28</sup> provide an extraordinary account of the anesthetic management with endotracheal cyclopropane and ether as well as the postoperative care and complications of Dr. Blalock's first 100 patients undergoing the Blalock-Taussig shunt operation; these patients ranged in age from 10 weeks to 20 years, and 5 died during or immediately after operation whereas another 17 died later in their postoperative course. The authors contend that anesthetic management may have played a role in 9 of the deaths. These were remarkable achievements nearly 50 years ago when cardiovascular diagnoses were most uncertain even in the best centers, patients usually were operated late in their disease and in desperate condition, and modern postoperative cardiopulmonary monitoring and support were unknown.

### **The Pediatric Anesthesiologist**

Prior to 1946, few physicians devoted their clinical practice to anesthesia, let alone to anesthesia for children. Special pediatric anesthesia equipment, for the most part, was contrived by the individual practitioner. Those physicians who did commit their energy and talents to pediatric anesthesia and to the training of others in the care of infants and children deserve recognition and praise for their difficult pioneering work.

The first pediatric anesthesiologist that the author could glean from the historic record was Charles H. Robson, MD, a McGill University medical graduate who, after 1 year's formal training and 3 years' practice as the senior ranking anesthetist of the Canadian Expeditionary Force during World War I, assumed



in 1919 the full-time position as Chief Anesthetist at Toronto's Hospital for Sick Children.<sup>15</sup> He describes in 1936, in a candid and yet alarming account, open drop ether administration without tracheal intubation as their routine anesthetic. This was the "standard of practice" at the time, although Dr. Robson acknowledges that cyclopropane with tracheal intubation using a "soft rubber catheter which fits gas tightly" proved preferable for complex procedures; he does not state whether ventilation was assisted or controlled.<sup>41</sup> Clearly, the safety of the child rested with the extraordinary skill of the practitioner in assuring patency of the upper airway without a tracheal tube and in gauging the depth of anesthesia to meet operative requirements without ventilatory depression. The pediatric anesthesiologist of today probably could have learned some valuable airway management skills from Dr. Robson and his colleagues.

In the mid-1930s, Dr. Philip Ayre, a visiting anesthetist at the Babies' Hospital, Newcastle-Upon-Tyne (England), developed an especially suitable pediatric anesthesia breathing system for use with tracheal intubation during repair of cleft lip and palate deformities in infants.<sup>4</sup> The key element, the "t" piece through which fresh gases are introduced at a relatively high flow rate, forms the basis for the modern semi-open pediatric anesthesia systems as well as many infant mechanical ventilator gas circuits. This piece was one of the first important mechanical innovations in anesthesia practice to compensate for the special physiologic needs of infants and small children during anesthesia.

In 1938, M. Digby Leigh, MD, another McGill University medical graduate who trained with Dr. Ralph Waters at the University of Wisconsin in the first anesthesiology residency program in the United States, became the first full-time director of anesthesia at the Montreal Children's Memorial Hospital. He invented pediatric anesthesia apparatus, performed clinical studies, taught residents, and, with his colleague Dr. Kay Belton, wrote "Pediatric Anesthesia," the first book in the new subspecialty.<sup>15</sup> Dr. Leigh continued in that position until 1947 when he left to become director of anesthesia at the Children's Hospital of Los Angeles.

## 1946 TO 1959

### Pediatric Anesthesiology as a Subspecialty

Robert M. Smith, MD, a Harvard Medical School graduate who trained in anesthesiology in the military during World War II, returned to Boston in 1946 and decided to devote his entire career to pediatric anesthesiology. He joined the newly appointed Ladd Professor of Pediatric Surgery, Robert Gross, as director of anesthesia at the Children's Hospital. Dr. Smith, the father of pediatric anesthesiology in the United States, contributed extensively to the clinical appreciation of the unique anatomy and physiology of the newborn and young infant as they apply to anesthetic care. He proved the safety and efficacy of tracheal intubation and muscle relaxants in pediatric patients, trained future leaders in the subspecialty, and wrote the first truly comprehensive textbook of pediatric anesthesia which remains current under new editorship in its fifth edition.<sup>37</sup>

In addition to Dr. Smith, throughout the late 1940s and 1950s a small group of talented and dedicated anesthesiologists concentrated their efforts on the anesthesia care of children. Among those who stand out for their contributions are the following: Dr. C. Ronald Stephen, Dr. Digby Leigh's successor in Montreal, who invented pediatric breathing apparatus, trained numerous residents, and wrote an introductory textbook of pediatric anesthesia; Dr. Margot van Deming, who became the first full-time director of anesthesia in 1950 and worked closely