

Jerrold Lerman  
*Editor*

# Neonatal Anesthesia

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 Springer

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## Foreword

*“The anesthesiologist...who has to spend more than a half hour in putting an infant to sleep because of unavoidable difficulties, and who during this time makes no excuses for his slowness and resorts to no drastic expedients to impress the onlookers or to console the impatient surgeon, is a gift beyond price to the welfare of children who are entrusted to his care in the operating room”.*

Willis J. Potts, *The Surgeon and the Child*, 1959

Those of us who have been privileged to practice neonatal anesthesia have indeed enjoyed a special relationship with our surgeons. We have also had to meet the challenges of working in one of the most demanding of the anesthesia subspecialties. The technical aspects of our practice require a level of precision and an attention to detail unparalleled in other areas of anesthesia practice. Successful perioperative management of the newborn requires obsessive monitoring and the potential for rapid and appropriate therapeutic responses based on a comprehensive knowledge of neonatal physiology and pharmacology. The neonatal anesthesiologist assumes a daunting responsibility—his patients are at a critical stage of development—and they are in the prelude to a potential lifetime of achievement.

Neonates have been given anesthetics since 1847, but the real history of neonatal anesthesia did not begin until halfway through the twentieth century. I started my training in pediatric anesthesia in 1967 at a world renowned Canadian children’s hospital. One day I was assigned to assist with the anesthesia for a newborn with a pre-ductal coarctation of the aorta. I was told that the way to manage this patient was to give a large dose of d-tubocurarine and to ventilate with oxygen. My monitors were an esophageal stethoscope, an electrocardioscope, an oscilometer, and a rectal temperature probe. What a long way we have come in the past 40 or so years!

It is most appropriate that a comprehensive book devoted to neonatal anesthesia should be produced at this time. There has been a progressive accumulation of knowledge related to the subject over the past few decades. Well designed studies have been completed which now permit an evidence-based approach to neonatal anesthesia practice. In addition, simultaneous widespread advances in medical technology have presented us with efficient new means to improve all aspects of the care of small infants. All of this has resulted in a rapid evolution in our management strategies for the newborn. The neonatal anesthesiologist can now very safely apply a full range of modalities to prevent pain, to optimize the perioperative physiological status, and to contribute very significantly to the success of the surgery.

Dr. Lerman has very extensive personal experience as a clinical neonatal anesthesiologist, gained in the very busy neonatal surgical service at the Hospital for Sick Children, Toronto, and subsequently at the Buffalo Children’s Hospital and the University of Rochester. As an investigator, he has contributed significantly to our knowledge. He has recruited an outstanding international team of contributors, each an expert in his field, to compile this source book for the practitioner.

BC, Canada

David J. Steward, MBBS, FRCPC



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## Acknowledgments

I wish to thank my wife, Robin, and my daughters, Ashley and Courtney, for their endless support and patience in undertaking this project.

I also wish to thank Dr. Robert E. Creighton and Dr. David J. Steward for their guidance and mentorship in shaping my academic career as a pediatric anesthesiologist.

Finally, not a day goes by that I do not reflect on the two anesthesiologists whose teaching, advice, influence, and mentoring set a trajectory for my academic career in pediatric anesthesia that would not have been possible otherwise: Drs. George Gregory and E.I. Eger II.

Thank you all.

Jerrold Lerman, MD, FRCPC, FANZCA





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David J. Steward

## Early Times

Diethyl ether was administered during operations by Crawford Long in 1842, but it was the demonstration by William G. Morton in 1846 at the Massachusetts General Hospital that led to the widespread introduction of general anesthesia. However the benefits of anesthesia during surgery were not immediately or universally applied. “They don’t feel it like we do” was a saying held to be true by physicians and surgeons long after 1846 [1]. In 1847 one third of the surgical operations at the Massachusetts General Hospital, the site of Morton’s demonstrations, were performed without anesthesia [1]. Anesthesia was selectively applied to those who it was judged felt pain more severely, i.e., white, wealthy, and especially female patients. Infants were considered incapable of perceiving pain; indeed Dr. Abel Pierson stated that “infants could sleep insensibly even while undergoing surgery” [1]. Henry J. Bigelow considered that like the lower animals, the very young lacked the mental capacity to suffer pain [2]. Indeed, in the case of the neonate,

misunderstanding of their perception of pain persisted well into the twentieth century.<sup>1</sup>

During the second half of the nineteenth century and the early part of the twentieth century, the decision to administer anesthesia to a neonate to relieve the pain of surgery was inconsistent. This is perhaps not surprising given the primitive methods which were available to administer anesthesia, the rarity of neonatal surgery, and the fact that small infants could be quite easily restrained during an operation (in addition to the thought that they don’t feel pain anyway!). Reports of operations on “impervious rectum,” [4] strangulated inguinal hernia, and even meningocele [5] without anesthesia can be found in medical journals of this era.

However reports from this time period can also be found describing anesthesia administered to infants in the first month of life. John Snow preferred chloroform and wrote in 1855 “*Chloroform may be given with propriety to patients of all ages. I have exhibited it to several infants aged from ten days to three weeks*” [6]. He went on to say “*Chloroform acts very favourably on infants and children. There has, I believe, been no death from chloroform under the age of fifteen years.*” The most commonly described indication for elective surgery in neonates during these years was for correction of “harelip,” an operation that was frequently performed “*at the earliest period of life.*”<sup>2</sup> On Saturday 4th of

<sup>1</sup>As recently as 1976, a technique of “anesthesia” for ductus arteriosus ligation in preterm infants, which was totally devoid of anesthetic or analgesic agents, was reported from a large American University Hospital in a widely respected British journal. The authors stated “*No premedication was given. Just before the procedure, if necessary, a paralyzing dose of suxamethonium 1 mg/kg body wt. was given. No other anaesthetic agent was used...We have avoided the use of anesthetic or analgesic agents which in our opinion are unnecessary*” [3].

<sup>2</sup>Repair of cleft lip (“harelip”) today conjures up thoughts of a delicate procedure with carefully planned and positioned skin flaps sutured using many fine sutures in a procedure lasting an hour or more. In the 1850s the repair would require 3–5 sutures and would occupy 3–5 min at most.

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July 1857, an entry in the case books of John Snow [7] reads “Administered Chloroform at Kings College Hospital to an infant, 8 days old, previous to Mr Fergusson operating for hare-lip. The face piece was too large and the chloroform took very little effect.” Chloroform was administered on this occasion using Snow’s inhaler with a small face piece; the latter however was still too large for a neonate. According to Snow, the use of the inhaler permitted “a more gradual introduction of the agent than when administered on a sponge or handkerchief” [6].

The alternative method was to administer chloroform to the infant using a sponge. “Mr. Greenhalgh preferred a sponge to every other kind of apparatus. He had employed the chloroform in a great number of cases, and with success: one of the cases was an infant, three weeks old, for an operation for hare-lip” [8].

During the second half of the nineteenth century, neonatal surgery was limited to superficial lesions. Abdominal surgery was largely confined to the emergency management of incarcerated inguinal hernia. Imperforate anus of the low type was relieved by incision, often without anesthesia. There were also reports of successful operations on neonates under chloroform for high imperforate anus. Thoracic surgery was certainly not attempted. However during these years, great progress was achieved in basic surgical techniques and the prevention of infection. The concepts of antisepsis and asepsis were recognized and applied. Many of the congenital lesions that would much later become the field of the neonatal surgeon were being recognized—though only as curiosities [9].

It is during this time that the first books on pediatric surgery were being published and special hospitals for children were being established. The Hospital for Sick Children at Great Ormond Street in London (GOS) opened in 1852, and in the USA, Boston Children’s Hospital, which was modeled after GOS, opened in 1882 [9]. Other European and North American cities established children’s hospitals at about this time. “Pediatric surgery” in these early years involved mainly orthopedic procedures, neonatal surgery was rarely performed, but the children’s hospitals would serve as a site and a catalyst for the subsequent expansion of infant surgery.

In the late nineteenth century, progress was being made in the care of sick neonate and preterm infants. It was recognized that the survival of small preterm infants was improved if they could be kept warm. A warm-air heated incubator was developed by a French obstetrician, Stephane Tarnier, and installed at the Paris Maternity Hospital. This was based on a device for raising poultry, which Tarnier had seen at the zoological garden [10]. The design was improved by Pierre Budin, and his incubators were shown at the Berlin World Exhibition of 1896 by his associate Martin Couney, infants being provided by Dr. Czerny, who was the Professor of Pediatrics in the city. Couney later exhibited his incubators

in London and at the Pan-American Exposition in Buffalo, New York. He also opened an exhibit at the Coney Island fairground in New York, which ran until 1943. Infants in incubators were also displayed at various other public exhibitions and fairgrounds. The public was invited to pay 25 cents to view these infants in incubators, an unlikely start for the specialty of neonatology. Once having been used in an exhibit, many incubators were later sold to hospitals.

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## The Twentieth Century

In 1905 ethyl chloride was being used for brief procedures in infants as young as five days of age. It was administered using an inhaler [9, 11, 12]:

“A celluloid face-piece is generally preferable since it not only permits the anaesthetist to observe the patient more readily but also resists the action of the vapour better than rubber. For infants of a few days or a few weeks old I commence by spraying three cubic centimetres into the inhaler; for those of six months and upwards I give five cubic centimetres at once. The mask is then approached to the face but not pressed against it so that the baby has several breaths of air and vapour mixed; it is then more closely applied so as to exclude all air except that which is already in the bag, and in a few seconds the child becomes unconscious. When one is sure that the anaesthesia is deep and the surgeon has made his incision or begun the operation the mask should be removed from the face and a few breaths of air should be given. If it is desired to continue the period of narcosis for some time the mask should not be kept off for long but only raised occasionally for air. If the respiration indicates the lightening of the narcosis a few more cubic centimetres may be added to the bag; on these lines the anaesthesia may be indefinitely prolonged.”

Abdominal surgery for infants became established around the turn of the twentieth century with the introduction of surgical procedures for the relief of pyloric stenosis. Originally managed by gastroenterostomy, the lesion was later corrected by pyloroplasty [13] and finally by Ramstedt’s pyloromyotomy [14]. Though most patients were older, some neonates were operated upon for pyloric stenosis. Chloroform was preferred and the need for adequate and constant levels of anesthesia was recognized. Reporting success in their cases of pyloroplasty in the *Lancet*, Cautley, and Dent in 1902 state: “Unless the patient is deeply under the influence of chloroform (which certainly appears to be the best anaesthetic) there is risk of protrusion of the intestine and rapidity of operating becomes a matter of great difficulty. On the other hand, in abdominal operations on very young children deep anaesthesia, unless most carefully induced and maintained, may lead to very sudden and alarming symptoms. Any interruption to the operative procedure while in progress would be a very serious matter, for if the patient is not deeply anaesthetised there is every likelihood of his recovering sufficiently to cry or to struggle. If any such