Coté and Lerman's

A Practice *of* Anesthesia *for* Infants *and* Children

Charles J. Coté • Jerrold Lerman • Brian J. Anderson

ELSEVIER

Coté and Lerman's A Practice of Anesthesia for Infants and Children

SIXTH EDITION

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Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information

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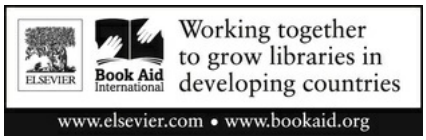

Dedication

We dedicate the sixth edition of A Practice of Anesthesia for Infants and Children *to physicians around the world who have the pleasure and responsibility of caring for children in the operating room, ICU, and other venues where anesthesia services are vital such as radiology, cardiac catheterization laboratory, and sedation services such as oncology. In particular, we acknowledge those practitioners who take care of children and deliver the best possible care with limited resources and at times with antiquated equipment, limited drugs, electricity, and even the availability of oxygen. Our specialty has grown exponentially in the past 30 years and as a result of new licensing laws, medications are now more thoroughly investigated before they are released for use in children. Ultrasound technology has made regional anesthesia and invasive line insertion far safer than in the past. The quality of airway devices continues to improve. Noninvasive continuous cardiac output devices may provide the next generation of monitors to safeguard the care of our children. Depth of anesthesia monitors also continue to evolve, but still remain unreliable in younger children; we hope that advances will ensure greater reliability in the infant and young child to assess the depth of anesthesia as well as to enable differentiation of moderate from deep sedation and deep sedation from general anesthesia.*

We also dedicate this book to the children to whom we provide anesthesia daily and to their parents/guardians to assure them that their children will receive the highest standard of care and will be as safe as possible from harm. Our specialty continues to investigate the possible adverse effects of anesthetics on the developing brain to determine whether the findings in newborn

animals are simply laboratory curiosities or are in fact translatable and potentially harmful to infants and children. Evidence at this time neither confirms nor refutes significant injury to the developing human brain. The challenge we face in our daily work is to reassure parents that anesthesia and the drugs we use are safe (to the best of our current knowledge) and that they do not pose real and substantive risks for their children.

This edition of A Practice of Anesthesia for Infants and Children *highlights key advances and questions in our specialty that we hope will continue to inspire anesthesiologists worldwide through the text, the web-based videos and illustrations, and the pocket shortcut card and phone app (Pedi Anesth).*

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Preface

A Practice of Anesthesia for Infants and Children, Sixth Edition, has continued to evolve from its humble beginnings in 1986 with only 304 pages in the 1st edition to more than 1200 pages in the current edition. Founding coeditors of this text Dr. John Ryan and Dr. Nishan Goudsouzian retired, and Dr. I. David Todres succumbed to lymphoma. Dr. Jerrold Lerman joined as a coeditor for the 4th edition, and Dr. Brian J. Anderson joined for the 5th edition; the addition of Dr. Anderson broadened the clarity and insight into basic pharmacology in all chapters.

The current edition includes 109 authors from five continents, 22 of whom are new contributors. The book continues to be a highly respected, evidence-based synopsis of the practice of pediatric anesthesia reflecting a broad perspective from a host of international experts. As was the case in past editions, many of the authors are board-certified in pediatrics and anesthesiology, surgery, and a number of pediatric subspecialties, enhancing the basic understanding of hematology, pulmonology, cardiology, nephrology, hepatology, and neurology. As in the last edition, the book is divided into 10 color-coded sections: Introduction, Drug and Fluid Therapy, The Chest, The Heart, The Brain and Glands, The Abdomen, Other Surgeries, Emergencies, Pain, and Special Topics. This format allows the reader to find chapters and topics of interest easily and quickly. We have shifted all but a few selected references for each chapter to the accompanying Expert Consult website with hypertext links to the original publications in an effort to contain the size of the book. Color illustrations, photographs, and graphics maximize clarity and enhance visual appeal; many new video clips, figures, tables, and appendices are also available online.

In keeping with our mission to create a comprehensive text, we have again sought contributions from a number of pediatric subspecialists who share their perspectives and insights into basic pediatric physiology and the pathophysiologic implications of disease in children. In each

case, the specialists have been paired with a pediatric anesthesiologist to ensure that the basic science is intertwined with a practical clinical perspective. These are the “Essentials” chapters.

Maintaining the past tradition, the largest chapter of the book is the pharmacology chapter, which now includes more than 2000 references. The chapter is written by all three editors, reflecting their different perspectives in pediatric pharmacology. We have maintained discussion of older and less frequently used medications to address the wide range of practices globally. The pediatric airway chapter includes an extensive discussion of supraglottic devices as well as emergency airway management strategies and equipment currently available for use in infants and children. There are many online videos illustrating their use.

All chapters on specialized topics, such as thoracic anesthesia, orthopedics, plastic surgery, general and urologic surgery, ophthalmology, otorhinolaryngology, burns, and cardiac topics, including physiology, cardiac surgery, cardiopulmonary bypass, medications for hemostasis, cardiac assist devices, and cardiac catheterization laboratory, have been updated.

The chapter on anesthesia in the developing brain has been substantively redacted to reflect the current state of knowledge on this subject and includes a comprehensive table of all published studies on this topic at the time of publication. Thus, readers are provided with ready access to the most important publications in this area. Chapters concerning anesthesia for extremely premature infants, the ex-utero intrapartum treatment procedure, trauma, and infectious diseases have also undergone significant revision.

Three new chapters focus on pharmacogenomics and the implications regarding drug interactions and drug metabolism, total intravenous anesthesia (TIVA), and on the perioperative management of oncology patients. The pharmacogenomic chapter underscores genetic implications of predicting drug effects and illustrates genetic variants that result in complications that are increasingly important in the day-to-day clinical management of patients. TIVA is becoming an increasingly popular technique as programmable pumps for drug delivery become more accessible.

The last 13 chapters of the book include management of trauma, cardiopulmonary resuscitation, malignant hyperthermia, ultrasound-

guided regional anesthesia, management of acute and chronic pain, anesthesia outside the operating room, PACU, sedation for diagnostic and therapeutic procedures, vascular access, infectious disease, medical simulation, and the exceedingly important topic of pediatric anesthesia in developing countries.

It should be noted that our text is accompanied by a website that contains many supplemental pictures, tables, figures, and video clips that will enhance the readers' experiences. The pocket reference card that provides general recommendations for doses of commonly used medications by weight and other useful guides such as LMA sizes, ETT sizes, and other quick references has now been expanded to include a phone-based application for both Android and iPhones that can be found with the search words “Pedi Anesth” that was sponsored by the Starship Children's Hospital in Auckland New Zealand. The phone application provides immediate weight-based dosing of all commonly used medications and other helpful algorithms. Additionally, the expanded version of the phone application contains color illustrations of common congenital heart lesions courtesy of Elsevier, as well as many additional tables and treatment algorithms.

As with all previous editions, this revision involved quite a journey reflecting a microcosm of the world and life in general. Many contributors again experienced various challenges such as loss of loved ones, personal crises, illness, and others during the writing of their chapters. Despite all these obstacles the authors have succeeded in crafting masterful chapters to create what we hope you will agree is an up-to-date, state-of-the-art text in pediatric anesthesia.

Once again, while assembling this new edition, the editors spent many days, evenings, and weekends debating controversial issues and crafting the language of the chapters such that all chapters were edited and reviewed by all three editors and common ground reached. This is an especially useful exercise since it improves the readability of the text and represents a fusion of the USA, Canadian, and New Zealand approaches to and understanding of pediatric anesthesia, which combines our global experience and understanding.

We believe that *A Practice of Anesthesia for Infants and Children*, Sixth Edition, continues to provide the framework for residency and fellowship training in pediatric anesthesia globally and will continue to

be a valuable resource for passing the subspecialty boards in pediatric anesthesiology, as well as a resource for practicing pediatric anesthesiologists and other pediatric care providers around the world.

Charles J. Coté

Jerrold Lerman

Brian J. Anderson

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We wish to thank our wives, husbands, significant others, children, friends, secretaries, and staff members who lent their support to this wonderful international family of experts that has come together to produce *A Practice of Anesthesia for Infants and Children*, Sixth Edition. In particular, we wish to thank the departments of anesthesiology, pediatrics, surgery, and internal medicine around the world who supported the academic endeavors of their staff and thus made it possible for them to contribute to the sixth edition. We thank Elsevier for their continued support of international education in less medically advanced countries by providing a variety of textbooks, including *A Practice of Anesthesia for Infants and Children,* to Fellows of the World Federation of Societies of Anesthesiologists as well as other fledgling programs, particularly those in sub-Saharan Africa. It is through such international endeavors that we ensure the global availability of the most recent advances in our specialty.

The editors wish to dedicate this edition of the book to honor the passing of Richard J. Kitz, MD, the chairperson who gave Dr. Coté the editorship of this book in 1982. Without his foresight, encouragement, and support, this book may never have been created.

Charles J. Coté

Jerrold Lerman

Brian J. Anderson

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SECTION I

Introduction

OUTLINE

1

The Practice of Pediatric Anesthesia

Charles J. Coté, Jerrold Lerman, Brian J. Anderson

IN THIS CHAPTER, WE outline the basis of our collective practice of pediatric anesthesia. These basic principles of practice can be applied regardless of the circumstances; they provide the foundation for safe anesthesia.

Preoperative Evaluation and Management

Parents and Child

Anesthesiologists must assume an active role in the preoperative assessment of children. Ideally, the same anesthesiologist who performs the preoperative evaluation will anesthetize the child. The preoperative evaluation should include a complete review of the birth, medical, surgical and family histories; a review of the medical record; evaluation and review of laboratory, radiologic, and other investigations; and physical examination of every child who is to be anesthetized (see Chapter 4). When appropriate, the child should receive preoperative medical therapy to optimize his or her medical conditions (e.g., a child with reactive airway disease) before receiving anesthesia. In addition, the emotional state of the child and family must be considered and appropriate psychological and, if necessary, pharmacologic support provided. The anesthesia team, working in concert with surgical colleagues, nursing, and child-life specialists (e.g., the use of iPad, movies, play therapy, or games) should find appropriate and creative techniques to prepare the child and family for the surgical experience (e.g., using videotapes, booklets, hospital tours, and/or trained paramedical personnel). The marked increase in the number of outpatient surgical procedures has reduced the time available for the anesthesiologist to interact with the family and the child preoperatively. Despite the reduced contact time, these support strategies should continue to be included in the preoperative assessment.

Familiarity with a child's clinical and psychological status as well as the parental concerns is essential to delivering quality anesthesia care. To achieve the very best outcome for each child, it is essential to meet with the child and the parents (or caregiver or legal guardian) together and establish rapport preoperatively. If the family speaks a different language

than the anesthesiologist, then a medical interpreter should be sought.

Many developmental issues are related to the hospital experience. For example, toddlers fear separation from their parents, younger children fear mutilation from their surgery, and teenagers fear loss of control, awareness, and pain (see Chapter 3). When conducting the preoperative interview, speak directly to the child (who is old enough to understand [usually age 5 years and older]) and explain what anesthesia involves and what will transpire when they enter the operating room in terms that are age appropriate. Children at the age of reason have the same fears as adults but may have greater difficulty articulating them. For example, identify the key elements that distinguish "sleep" from anesthesia medicine from the sleep they experience at home. Explain that even if children undergo anesthesia for hours, they will feel as if they were unconscious for only a few minutes. Children should be reassured that unlike sleep at home, *the anesthetic prevents them from feeling anything during surgery, that they will not wake up during the procedure, and that they will awaken after the surgery.*

How anesthesia will be induced should be explained to the child in terms that are appropriate for the child's developmental level. For young children, one can describe that he/she will breathe "laughing gas" through a flavored mask, with a flavor that he/she chooses. Older children can be given the option to receive anesthesia either intravenously (IV) with nitrous oxide by mask, topical local anesthesia cream (e.g., eutectic mixture of local anesthetics [EMLA]) or vapocoolant such as Pain Ease (Gebauer Chemicals, Cleveland, OH) to establish IV access painlessly; or if they are afraid of needles, they may choose to receive anesthesia by an inhalational induction. Child-life specialists can be particularly helpful in demonstrating the anesthesia mask and circuit, illustrating that an IV is just a plastic tubing and not a needle and even decorating the mask with stickers and picking flavored scents.

If the parents will be present at induction of anesthesia, it is preferable that they attend a preoperative instructional session during which a typical induction is described along with the child's responses, perhaps complemented by a video of an induction. The parents should be instructed on how they might assuage their child's concerns, and questions from the parents should be answered. It is challenging to expect parents to cope with their child's induction without providing any

preoperative instruction and teaching. Specific changes that might be observed in their child during anesthetic induction can be addressed as follows:

1. As your child is anesthetized, his or her eyes may roll up: "You might see your child's eyes roll up and this might be disturbing to you, but this is completely normal and expected; it happens to all of us when we fall asleep; it is just that we are not looking for it."
2. "As children fall asleep the structures in the neck relax so they may snore or make other noises from their throat; if your child does this, it is completely normal."
3. "As the anesthetic reaches the brain, the brain sometimes gets excited and causes movements of the arms and legs that are without purpose, or it may cause them to turn their head from side to side. This means the anesthetic is having its effect and even though your child appears to be partly awake, he or she has received enough anesthesia to ensure that he or she does not remember this."
4. "If your child becomes frightened, we will increase the amount of the anesthesia medicine rapidly and calm your child as quickly as possible."
5. If anesthesia is induced intravenously, the parents should be informed that their child might suddenly become limp, stop moving and breathing, and appear pale. These are all normal reactions.

At the same time, parents should not be pressured to be present for induction of anesthesia. If the parents are present at induction, it must be clear that they may be asked to leave the operating room if a new or additional risk to the child surfaces during the induction. Parents should be informed that their presence at induction is for their child's benefit and that their presence is a privilege, not a right. Moreover, in some circumstances it may not be in the child's best interest for parents to be present at induction, such as when the health care team could be distracted when everyone's attention should be focused on the child.

A simple explanation of the monitors to be used during anesthesia can be interesting to children and reassuring to parents. For example, the pulse oximeter can be described as a *"Band-Aid–like device"* that lights up