
‘An Overview of TCI and TIVA’ was written by two pioneers in the field of targeted drug delivery in anesthesia. Despite its small size, this book is a rich source of information on the structure, function, and clinical applications of target-controlled infusion (TCI) systems. Discussions on manually controlled infusion regimens of the most popular agents are not omitted either. A large number of data are presented in a concise yet comprehensive manner, and helpful clinical guidance is often provided. Important pharmacokinetic and pharmacodynamic principles, which relate to the operational standards of TCI systems, are analyzed in chapters II and III, whereas explicit references to pharmacokinetic and pharmacodynamic functions are made throughout the book. The language, although nonmathematical, relays a scientific strength. The presentation is simple, but not simplistic. The text has the appearance of ‘class notes’ rather than a formal manual; however, this feature enhances the tutorial dynamics of the book and should attract individuals involved in learning such as anesthesia residents and specialists flirting with total intravenous anesthesia (TIVA).

In their opening remarks, the authors argue the potential advantages of TIVA over inhalation anesthesia. Although current technology still operates far from realizing the concept of an ‘intravenous vaporizer,’ TCI systems have been developed and are being improved continually to enable accurate and efficient anesthetic control.

In chapter I, the authors focus on the definition, development, and functional components of TCI systems. A distinction is made between open-loop operators and closed-loop control systems, while a simple case of plasma controlled infusion is analyzed through the bolus-elimination-transfer principle. The authors, with references from the relevant literature, argue that TCI is preferable to manually controlled infusions because of the improved safety and efficacy of intravenous anesthetic. However, there is still an obvious lack of compelling evidence that a TCI approach is clinically superior to manual control of anesthesia. A description of the different types of controls used in TCI systems is missing. The authors represent two different schools on control methodology used in TCI applications: One is the proportional-integral-derivative technique, and the other is model-based, patient-adaptive control. Issues such as the engineering principles of various control methods or characteristics of optimum control for TCI applications could have been discussed. Despite its attractive simplicity, the general level of the book is high, and some additional, in-depth analysis of the issues above would certainly interest at least research-oriented readers.

In chapter II, a short introduction to basic kinetic principles is followed by comments on pharmacokinetik models for commonly used TCI agents. The authors do not elaborate on the kinetics of individual agents, but they do provide useful clinical information mostly by comparing different pharmacokinetic models for the same agent. For example, the effect of covariates like age, weight, and sex on the kinetics of various agents is discussed, while five tables at the end of the book provide a complete account of the most popular pharmacokinetic and pharmacodynamic models for commonly used agents. The next three sections of this chapter, ‘Accuracy of target-controlled infusion systems,’ ‘Which patient weight should be used for TIVA and TCI?’ and ‘Effect-site-targeting, time to peak effect and k_{eoa},’ go further and deeper in TCI analysis. Such high-quality, processed knowledge is difficult to dissect out of a ‘busy’ textbook or the technical text of a scientific paper. Creative anesthetists and junior investigators will find these sections especially appealing. The authors analyze, among others, the TCI mechanics of effect site targeting using different time constants but the same pharmacokinetic sets. Clinical meaning is provided through plenty of paradigms and graphs.

Chapter III deals with the pharmacodynamics of propofol and opioids. Sedation and anesthesia are examined separately, while much space is devoted to reporting concentrations for various end points from different studies. The value of this report is doubtful, because the interindividual variability in pharmacodynamics is high and the authors rightfully advice TCI operators to use titration. Surrogate measures of drug effect and methods of pharmacodynamic analysis are missing. Nonetheless, important pharmacodynamic information (e.g., time to peak effect principle and effect site targeting) was presented as part of the effect site targeting discussion in chapter II. The section on pharmacodynamic interactions and their potential clinical implications is nicely written.

Chapter IV is dedicated to practical aspects of TIVA and TCI operation. Sections dealing with manually controlled infusions for propofol and opioids will certainly interest anesthetists residing in the United States, because their access to TCI technology is limited to the investigational arena. The presented material, though, is inadequate. Obvious reasons are the complicated calculations required for the various infusion algorithms and the limited research in the field. The clinical management of blood- and effect site-targeting infusions in ‘healthy’ and ‘high-risk’ patients is described in an instructive manner, while six case studies presented in the last chapter are also helpful to that end. Much of the perioperative information not directly related to the management of TIVA could have been omitted. On the other hand, enrichment of this series with more challenging cases (e.g., awake fiberoptic intubation in normal-weight or obese patients, awake craniotomy, patients with sleep-disordered breathing, and postoperative pain management) would be more likely to set off the clinical benefits and problems of automated drug delivery.

In conclusion, I found this booklet quite valuable. Anesthetists who ask questions about the physiology and clinical applications of TCI systems will find most of the answers they need in this book. TIVA lovers will get the stimulation to try something new. Junior investigators in the field will find certain parts of the text very enlightening, as well as thought provoking.

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Practicing anesthesiologists and intensivists have come to take capnography for granted in the monitoring of surgical and critically ill patients. Although many standard anesthesiology texts contain a chapter about this important and useful technique, a comprehensive update to date treatment of the subject is not easy to find. Capnography: Clinical Aspects fills this void.

The book is a multi-authored effort edited by two academicians and an engineer working in industry. The editors acknowledge significant overlap between chapters and characterize the book as more of a ‘symposium’ than a textbook. There is adequate continuity of style.
between chapters, but as with any book written in this format, some chapters are more interesting to read than others.

The book is organized into four parts. The first part is meant to be clinical and describes the interaction of respiratory, cardiovascular, and metabolic systems in determining the amount of exhaled carbon dioxide as measured by capnography. This is followed by parts on basic carbon dioxide physiology, the history of capnography, and the technology of capnography.

The clinical part is divided into four sections: Ventilation, Circulation, Metabolism, and Organ Effects. The ventilation section is further divided into subsections on breathing assessment, airflow management, monitoring of ventilation, weaning, and special situations. The first chapter (written by two of the editors) is a well-written introduction to time-based capnogram interpretation, the most commonly used form of capnography in the operating room setting. Of particular value is the introduction to the volume-based capnogram, a topic not commonly detailed in anesthesiology texts. Subsequent chapters discuss capnography outside the operating room and in the prehospital setting for airway management, in particular to confirm tracheal intubation. The chapter on airway management in the intensive care unit includes a section on using capnography to confirm proper orogastric and nasogastric tube placement. The chapter on airway management in the operating room includes sections on confirming tracheal intubation and recognizing endobronchial tube placement.

The chapter describing the use of capnography to monitor ventilation during anesthesia includes interesting comments on the Food and Drug Administration checkout relevant to capnography. This chapter also includes sections on equipment troubleshooting and how capnograms can be affected by positioning, pulmonary pathology, and several particular situations such as one-lung ventilation, laparoscopy, neurosurgery, cardiac surgery, tourniquet release, and high-frequency jet ventilation. Other chapters in this section focus on the use of capnography during transport and how it can be used in the field as a way to avoid deleterious effects of unintentional hyperventilation after intubation.

A particularly comprehensive chapter describes the unique physiology and technological limitations of capnography in neonates and infants. Other chapters describe capnography in the sleep laboratory, capnography as a feedback tool for behavioral therapy in various disorders, and how the capnogram is affected by alterations in physiological and technical limitations in high- and low-pressure environments.

Chapters are also included on sedation and noninvasive ventilation. These chapters are valuable for their descriptions of how end-tidal carbon dioxide can be sampled during spontaneous ventilation in nonintubated patients and the clinical utility and limitations of end-tidal carbon dioxide as a method of estimating arterial carbon dioxide tension (PACO₂) in noninvasive ventilation.

Chapters relevant to critical care describe the use capnography to optimize tidal volume, alveolar minute ventilation, and positive end-expiratory pressure to wean patients from mechanical ventilation. These chapters also describe the use of volumetric capnography to assess carbon dioxide production and how the capnogram is affected by positive end-expiratory pressure, unilateral lung injury, tracheal gas insufflation, and various high-frequency ventilation modes.

The circulation subsection includes chapters on how end-tidal carbon dioxide monitoring can be used to assess circulatory status during cardiopulmonary resuscitation and for prognostication during cardiac arrest in medical patients as well as the use of end-tidal and tissue carbon dioxide monitoring techniques to assess oxygen delivery in shock states. This section includes an elegant physiologic description of changes in alveolar dead space with pulmonary embolism and the use of capnography in diagnosis and treatment of pulmonary emboli and gas embolization in addition to a chapter on the utility of volumetric capnography for estimating arterial PACO₂ in patients with acute respiratory distress syndrome.

The chapter on noninvasive pulmonary blood flow measurement describes complete and partial carbon dioxide rebreathing techniques as alternatives to invasive cardiac output monitoring. A variety of clinical scenarios illustrating the use of these techniques sets this chapter apart from other descriptions of this topic.

The metabolism subsection includes a single chapter describing alterations in normal physiology induced by surgery and anesthesia that affect carbon dioxide elimination. The chapter discusses alterations in ventilation, circulation, and carbon dioxide metabolism that are influenced by temperature alterations, various anesthetic techniques, and pharmacologic agents as well as particular intraoperative situations such as laparoscopy, tourniquet release, vascular cross clamping, and cardiopulmonary bypass.

The final chapter of the ventilation section describes the effects of hypercapnia and hypocapnia on tissue oxygenation and perfusion, focusing on the central nervous system, respiratory system, and cardiovascular system. This is an excellent introduction to the effect of carbon dioxide at the organ, tissue, and cellular/molecular level and could have been included in the section on physiology.

The physiology section includes a chapter on carbon dioxide physiology, which describes inherited and acquired mitochondrial and enzyme disorders as well as pharmacologic agents that alter carbon dioxide production. The chapter also discusses carbon dioxide embolism and the increase in PCO₂ during apnea testing for brain death. There is a complete if somewhat standard chapter on acid–base physiology, followed by an excellent description of how capnography can provide information on ventilation/perfusion mismatch from a physiologic standpoint, including examples of various disease states. Subsequent chapters describe clinical correlates of alterations in normal time and volume capnographic tracings and how capnograms can provide clues to the underlying pathophysiology.

A particularly interesting chapter in this section summarizes a biomedical engineering approach to illustrate the underlying anatomical and physiologic processes that result in a normal volumetric capnogram. A mathematical model that accounts for bronchial airway structure, gas convection and diffusion, and the carbon dioxide release from alveolar capillary blood is shown to generate a computed washout curve that shows remarkable agreement with an experimentally measured capnogram from a healthy human subject. This illustrates the utility of physiologic modeling as a useful tool for investigating potentially complex pathophysiologies without placing patients at risk.

A unique historical section describes the evolution of time and volumetric capnography with many interesting anecdotes, as well as a first-person account by Smallhout, an early proponent of capnography. A selection of capnographic tracings corresponding to clinical events that he made over a 20-yr period is one of the highlights of this book. Without reading this section of the book, few people would realize that the impetus for carbon dioxide analyzer development was to investigate the cause of death in patients who turned out to be rebreathing due to a channeling issue through carbon dioxide absorption devices, or that carbon dioxide analyzers enabled a reduction in mortality for polio patients by allowing clinicians to titrate ventilation to expired carbon dioxide instead of adjusting ventilation based on their weight.

The technological section fulfills the editors’ wishes for providing clinicians with information necessary to appreciate the mechanism, design, and limitations of devices for measuring carbon dioxide. Various chapters address technical specifications and standards (e.g., accuracy, range, drift, response time, interfering gases, alarm systems, calibration) for carbon dioxide analyzers and describe technological limitations for flow measurement, required to estimate carbon dioxide production. Another chapter describes various methods for carbon dioxide detection, including infrared, photoacoustic, colorimetric, and mass spectrometry methods. Unfortunately, Raman spectroscopy is not included simply because it is not currently commercially available. This chapter also includes a discussion of mainstream versus side-stream carbon dioxide analyzers.
The book ends with a mini-atlas of capnographic waveforms typifying various physiologic states, which is useful although not exhaustive. As the editors acknowledge, there is a fair amount of redundancy; as an example, the fact that highly sensitive colorimetric carbon dioxide indicators can yield false positives with esophageal intubation is mentioned in multiple chapters along with the fact that false negatives in cardiac arrest have led to the removal of correctly placed endotracheal tubes. Other recurring themes include the predictive value of end-tidal carbon dioxide in assessing arterial Pco2 and the utility of volumetric capnography. In general, I found the multiple perspectives to be helpful instead of confusing or irritating. As with any book, the onus is on the reader to formulate his or her judgment with the assistance of the most recent literature.

The overall introduction to the book and the introduction chapters for each section are very short and could have been used to provide the reader with a more substantial description of the basic concepts or objectives of each section. The section and subsection titles are somewhat arbitrary, and some chapters are in fact assigned to their own sections. Although the terminology is relatively consistent, the book could also use a more comprehensive list of abbreviations and acronyms used in various chapters. I found most of the typographical and page-setting errors to be minor (with the exception of a reference to ‘title’ volumes). In spite of these limitations, the book admirably maintains its focus on capnography; readers interested in the latest tissue oxygen tension (P02) monitoring techniques, for example, will have to look elsewhere.

In summary, Capnography: Clinical Aspects is a very readable introduction to a topic addressed by few textbooks. It is useful as a reference primarily because of its comprehensive index and contains much information useful to the practitioner of critical care as well as anesthesiology. It addresses the physiologic and technological considerations that need to be understood to make capnography a clinically useful tool and should be standard reading for those who depend on it as a basic anesthetic monitor.

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