

Faust's

ANESTHESIOLOGY REVIEW

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Faust's Anesthesiology Review

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Faust's Anesthesiology Review

Fifth Edition

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*To my wife Laralee M Trentman,
for her loving support during this and our every endeavor,
and to the memory of my father Lee Trentman.
I can't thank you enough.*

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Dear Reader,

Welcome to the fifth edition of *Faust's Anesthesiology Review*. On behalf of our team of Associate Editors and the production staff at Elsevier, I want to thank you for investing your time and resources in this textbook. We believe your investment in time and study will be rewarded with greater current knowledge of anesthesiology and ultimately, improved patient outcomes.

This edition of *Faust's Anesthesiology Review* differs from previous editions in several important ways. Since publication of the fourth edition, we have updated existing content and have asked experts to write new chapters on key and emerging topics vital to anesthesia providers. A few examples include new chapters on sugammadex, extra corporeal membrane oxygenation (ECMO), transvascular aortic valve replacement (TAVR/TAVI), and complex spine surgery. New information on practice management topics, such as Medicare's Quality Payment Program with its separate Merit Based Incentive Payment System (MIPS) and Advanced Alternative Payment Model (APM) pathways, have also been added.

We have many new contributors to this edition of Faust and several new editors. We are indebted to all of our authors for their expertise and contribution to the fifth edition. As with the fourth edition, the chapter authors are not only from Mayo Clinic but also many other prominent medical centers across

the USA and beyond. Consistent with the spirit of the previous editions, we have sought to not only prepare trainees for board exams, but also to provide a resource that is valuable to any anesthesia professional seeking to remain current and capable of solving everyday practice problems.

Finally, feedback from readers is a powerful guide to improving future editions of this work. We would very much appreciate hearing from you regarding ways we can make this textbook more useful as you seek to provide the best possible care for your patients. Please contact me with your suggestions (trentman.terrence@mayo.edu).

Best regards,

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FOREWORD

Every generation in a medical specialty has unique experiences, encounters medical conditions that span that generation's professional practice, and has a handful of texts that contribute to their education. For example, my generation, ranging roughly from 1980 through today, was there to care for the first patients with HIV infection and has seen this devastating infectious problem and its treatment evolve. We were amazed with the first comprehensive U.S.-based textbook, *Anesthesia*, edited by Dr. Ronald D. Miller and subsequent books from Drs. Robert K. Stoelting, Paul G. Karash, Bruce F. Cullen, G. Edward Morgan, Maged S. Mikhail, and others. Their initial textbooks greatly influenced my generation of anesthesiologists.

In 1991 Dr. Ronald J. Faust and his Mayo Clinic colleagues introduced their novel "anti-comprehensive" anesthesia textbook. This text took the tack that many anesthesiologists needed a quick review of key clinical and basic anesthesia issues. Their resulting text contained short chapters that were easy to read and contained the most important information related to their topics. They triggered recall in readers who had previously studied these topics in the depth provided by major comprehensive texts. This relatively new approach to adult education proved to be wildly popular.

This year *Faust's Anesthesiology Review* provides a fifth edition of what has become a primary textbook for all trainees in the anesthesia profession. Of note, only one of the original editors of the first edition, Dr. Steven H. Rose, remains. He played a significant role in developing the concept of short chapters for adult learners that made the book so useful. Thousands of anesthesiologists in my generation have turned to previous Faust editions for quick review of important issues in clinical practice and preparation for board examinations. Given the success of previous editions, I have no doubt that the next generation of anesthesiologists will find this fifth edition provides them with the same high priority review of important knowledge that my generation found in the first edition.

A hearty "well done" to the editors of this fifth edition.

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May 2018

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SECTION 7C

Specialty Anesthesia: Cardiac

Chapter 132 Percutaneous Approaches to Valvular Disease: Transcatheter Aortic Valve Replacement (TAVR) & Transcatheter Mitral Valve Repair (TMVR)

Video 132-1 2-D TEE video showing the MitraClip delivery system steering catheter placed across the interatrial septum and into the left atrium, [413](#)

Video 132-2A 3-D TEE video of the mitral valve before placement of the clip, [413](#)

Video 132-2B 3-D TEE video of the mitral valve color flow demonstrating the regurgitant jet through the mitral valve before placement of the clip, [413](#)

Video 132-2C 3-D TEE video of the mitral valve after placement of the clip, [413](#)

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1

Medical Gas Supply

MARTIN L. DE RUYTER, MD

Medical gases most common to anesthesia include oxygen (O₂), nitrous oxide (N₂O), and air. Historically the less frequently used medical gases include helium (He), nitrogen (N₂), and carbon dioxide (CO₂), but there has been a recent surge in the use of CO₂ secondary to the advancement of laparoscopic and robotic procedures. Several governing bodies regulate medical gases, but the containment and delivery of these gases via a medical gas cylinder system is controlled via standards set by the U.S. Department of Transportation. Medical gas cylinders are the foundation for central pipeline supply of gases to the operating room (OR) and hospital. Additionally, a cylinder system (typically the smaller E cylinders) exists in the OR as a backup for unanticipated failure of the central pipeline supply (Figs. 1.1–1.3).

Medical gas cylinders store compressed gas. Cylinder sizes and thus capacity vary and traditionally have been designated by letters, with “A” being the smallest and “H” being the largest (most commonly). The new naming system begins with the letter “M” to signify “medical” gas and the number that follows is the capacity of the cylinder expressed as cubic feet (Table 1.1). Most clinicians remain familiar with older nomenclature and that will be used in this chapter. H cylinders are large-capacity storage containers that typically provide the central pipeline supply of medical gas that is piped into the OR. E cylinders are smaller, portable, and are the most commonly encountered cylinders in the OR. A typical anesthesia machine will have an attachment for two (O₂ and N₂O) or three (two O₂ and one N₂O) E cylinders. E cylinders are also commonly used to supply O₂ to patients during transport. Cylinders are color coded according to the gas they contain. Unfortunately, there is no global agreement, and the colors in the United States are not the same as those accepted internationally. Table 1.2 lists the common medical gases, the cylinder capacity, the color of the cylinders, and the state (liquid/gas) under which medical gases are stored.

At ambient temperature, when gases are compressed and stored in cylinders, gases will either liquefy or remain in a gas state. When stored in medical cylinders, compressed O₂, He, and air remain as gases at ambient temperature. In contrast, N₂O, when compressed and stored in medical cylinders, becomes a liquid at ambient temperature. Knowledge of nonliquefied gases and liquefied gases allows one to estimate the amount of gas that remains in a cylinder as the gas is being consumed. As gas is consumed, the pressure gauge will decrease in a linear proportion to the cylinder’s remaining content. For example, an E cylinder filled with O₂ contains approximately 660 L of

nonliquefied O₂ at a pressure of approximately 2000 pounds per square inch (psi). When the gauge reads 1000 psi, approximately 330 L of O₂ remains. Therefore one can estimate how long before a cylinder will empty when delivering gas at a certain flow rate. An equation to estimate the time remaining in a cylinder is as follows:

$$\text{Approximate remaining time (h)} = \{\text{O}_2 \text{ cylinder pressure (psi)} / 200 \times \text{O}_2 \text{ flow rate (L/min)}\}$$

The volume remaining in a cylinder of liquefied gases, such as N₂O, cannot be estimated in the same manner. The pressure gauge of the N₂O cylinder reads the pressure of the small amount of vapor above the liquid. As gas is consumed, more gas moves from the liquid phase to the gas phase, maintaining the vapor pressure and, hence, the reading of the pressure gauge. Only when nearly all of the liquid N₂O is vaporized does the pressure start to fall. For example, a full E cylinder of N₂O contains 1590 L and reads 745 psi; this pressure will remain constant until nearly all of the N₂O is vaporized, at which point

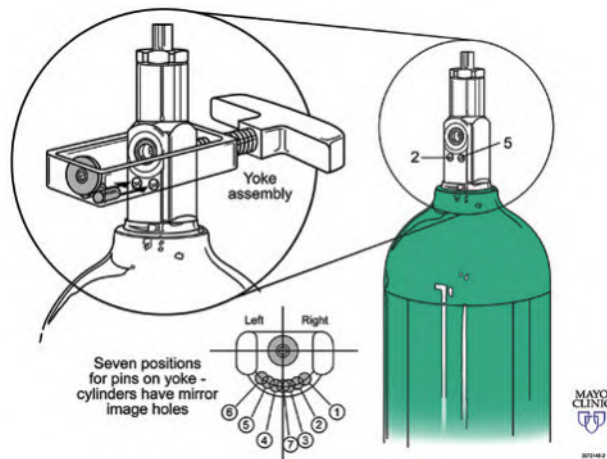


Fig. 1.1 The index safety system is one of several features of medical gas cylinders that is in place to ensure that the correct cylinder is attached to the correct gas inlet in the back of the anesthesia machine. Cylinders are color coded; each cylinder has a label identifying which gas it contains, and the cylinders attach to the back of the anesthesia machine using the pin-index safety system. Two pins incorporated into the yoke of the machine, just below the gas inlet, line up with two holes on the gas cylinder, allowing only the correct cylinder to be connected to the correct inlet. (From © Mayo Foundation for Medical Education and Research. All rights reserved.)