Book Review

Title: Cardiopulmonary Bypass Principles and Practice, 2nd Edition

Editors: Glenn P. Gravlee, Richard F. Davis, Mark Kuruz, Joe R. Utley

Publisher: Lippincott Williams and Wilkins, Philadelphia, PA

Contents: 5 Sections, 35 Chapters, 768 Pages

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Techniques and concepts in today's practice of cardiopulmonary bypass are being continually developed and challenged. These changes allow us, as clinicians, to refine and advance our practice for the treatment of heart disease in both adults and children. Techniques such as vacuum-assisted drainage, port-access surgery, rapid autologous prime, and plasmapheresis have expanded the perfusionist's role in the operating room as an integral member of the open-heart team. However, we must not forget that basic physiology and pathology give us the necessary foundation for sound clinical decisions regarding patient treatment.

The first edition textbook of Cardiopulmonary Bypass Principles and Techniques has been considered an essential contribution to the study of perfusion for both students and clinicians involved in cardiac surgery worldwide. One then could eagerly expect a second edition to follow with the same precision and knowledge for cardiopulmonary bypass techniques and complications, as well as recent changes and theories. Improving upon a very successful first edition may seem a daunting task however; editors Gravlee, Davis, Kuruz, and Utley have successfully followed their first publication with contributions from over 67 authors. A keynote change to this 2nd edition textbook is the addition of a well-known and respected perfusionist to the list of contributing editors, giving the text a much-needed perfusionist perspective to cardiac surgery.

The textbook begins with five sections logically delineating the various aspects of cardiopulmonary bypass from historical aspects to equipment, physiology, hematology, and clinical applications. Each of the sections include several chapters, ranging from two to thirteen, which thoroughly expand upon each section's details. This second edition text also includes a key points portion that follows each chapter, highlighting objectives from each chapter, making it easy for the reader to summarize the chapter's major contents.

Particularly impressive is the introductory section, chapters one and two, which eloquently describe the transition of cardiopulmonary bypass from an idea to physical development. Authors C. Walton Lillehei and Harris Shumacker, Jr. give an extraordinary personal perspective, with notable photographs, to the difficulties and obstacles that were met during the development of today's techniques and extracorporeal equipment.

Section two contains chapters 3–8 and overviews cardiopulmonary bypass equipment. This section has expanded in detail over the first edition textbook by dividing blood pumps, cardiotomy suction and venting, and circulatory assist devices into their own respective chapters. The chapter on blood pumps includes a much more detailed discussion of centrifugal pumps, along with addressing the several different commercially available designs from manufacturers and comparing each of their corresponding performance characteristics.

Chapters 4–7 include information on oxygenator function, circuitry and cannulation techniques, cardiotomy suction and venting, and hemofiltration and dialysis. The second edition text has included information regarding the recent practice of vacuum assisted venous drainage (VAVD) in the cannulation and circuitry techniques chapter.

Chapter eight, circulatory assist devices, contains the major types of the assist devices along with their specific complications. The authors here stress the importance of patient selection in ventricular assist device (VAD) success. Complications, an inevitable and sometimes overwhelming problem in assist devices, are addressed in this chapter. However, a comparison of complications related to each specific assist device may have been helpful. Additionally, since recent research and manufacturer design has allowed many patients to ambulate and return home with assist devices in place, it would have been valuable to convey these issues to the reader.

Section three, physiology and pathology, is the largest and most technical section. It serves to dissect the concepts and consequences behind the use of cardiopulmonary bypass in relation to each end organ system. The section logically begins with a chapter on blood-surface interactions and allows the reader to gather detailed information about the complex blood protein systems and blood cell reactions to cardiopulmonary bypass. Several approaches to control the blood-surface interface are discussed with surface-bound heparin, surface-modifying additives, and blood modification. Chapters 10–12 relate the topics of pulsatile bypass, hemodilution and priming solutions as well as hypothermia. Acid-base alterations during hypothermia are addressed along with the management strategies of pH-stat and alpha-stat blood gases. Hypothermia, while
an extremely beneficial adjunct to bypass, is not without con-
sequence and these effects are detailed in chapter 12.

The chapter on myocardial protection, extremely well refer-
enced and technically sound, dissects the pathophysiology of
myocardial injury into the three phases in which it can occur:
prior to, during, and following cardiopulmonary bypass. Est-
ablished strategies and elements of surgical myocardial pro-
tection are examined, addressing issues such as chemically
induced cardiac arrest, avoidance of edema, buffering acidosis,
and hypothermia. The authors also stress the management of
myocardial calcium, specifically in relation to ischemic-
reperfusion injury. Emerging myocardial protective strategies
look at the use of oxygen radical therapy, amino acid enhance-
ment, and adenosine. Nitric oxide, whether utilized through
supplementation in cardioplegia solution or through modula-
tion of endogenous sources is discussed as an experimental
strategy for myocardial protection.

The next three chapters include information on drug
pharmokinetics and pharmodynamics during bypass, the im-
mune and inflammatory response, and embolic events related
to the use of CPB. Chapter 14 Factors such as hypothermia,
generation of the systemic inflammatory response syndrome
(SIRS), pulsatile or nonpulsatile CPB, CPB circuit compo-
nents, and alterations in receptor function may all alter drug
action during bypass. The systemic inflammatory response is
significantly stimulated during bypass and much of the end
organ dysfunction following bypass can be related to this.
Chapter 16 relates that the most common manifestation of
emboli following CPB is cerebral injury, no matter what form
the emboli may come in.

The final five chapters of the section detail the responses of
the major organ systems: endocrine and metabolic system, pul-
monary, kidney, splanchnic and hepatic, and neurologic. These
chapters stress that cardiopulmonary bypass inflicts unique
physiologic alterations in all organ systems, ones not found in
many other surgical procedures. The recognition and manage-
ment of these physiologic consequences is critical in patient
care. Hematology is the title of section four and subdivides into
five chapters discussing anticoagulation for bypass, heparin
neutralization, and hematologic effects of cardiopulmonary by-
pass, along with management of coagulopathies, and blood
transfusion and conservation. Here the editors emphasize the
fragility of the patient hemostatic system and how clinicians
immensely alter it with the use of cardiopulmonary bypass and
by the administration of heparin and protamine. As most clini-
cians have seen, bleeding and associated coagulopathies fol-
lowing surgery can have a devastating consequence on patient
outcome. Understanding each of the components of the hemo-
static system along with any mitigating factors than may in-
fluence it is necessary in gauging a strategy for the treatment of
post-bypass bleeding. Additionally, while blood conservation
and transfusion practices have substantially evolved over the
years it is necessary to realize that different modalities exist in
cardiac surgery today for blood conservation.

The final section of the textbook is devoted entirely to clini-
cal applications and includes several chapters that address car-
diopulmonary bypass management in adults and pediatrics,
along with extracorporeal membrane oxygenation (ECMO),
non-cardiovascular applications of CPB, perfusion for the tho-
cracic aortic surgery, and port-access surgery.

Chapter 27–29 deals with the conduct of CPB, management
of unusual problems, and the termination of CPB respectively.
The chapter regarding cardiopulmonary bypass conduct has
superseded the first edition in providing a greater amount of
information on perfusionist responsibilities prior to and follow-
ing bypass, along with the importance of protocols and guide-
lines. New techniques of VAVD and retrograde autologous
priming (RAP) are reiterated here. Chapter 28, management of
unusual problems during bypass, has progressed from the first
dition by addressing problems associated with atherosclerotic
aorta, reoperative patients, and patients with religious objection
to transfusions.

Preparation for termination from bypass is a crucial time for
the perfusionist to begin to assess how the patient may or may
not respond to weaning from cardiopulmonary bypass. Knowl-
dge of how to hemodynamically assess the patient prior to
CPB separation, along with any potential problem situations
including right and left ventricular failure are all thoroughly
addressed in Chapter 29. Ventricular assist devices, specifi-
cally mentioned as equipment in section two, may need to be
reiterated here. This is of particular importance when ventricu-
lar support modalities such as inotropes, vasoconstrictors, va-
sodilators, or intra-aortic balloon pumps (IABP) are inad-
quate. Many centers are reporting excellent results with the
use of a centrifugal pump and an IABP to provide pulsatile
flow for short-term assist in post-surgical patients who fail to
wean from bypass.

Pediatric cardiopulmonary bypass is devoted entirely to
Chapter 30, which focuses on physiologic management, bypass
circuits, and termination differences for infant and pediatric
cardiopulmonary bypass. The use of deep hypothermic circu-
latory arrest (DHCA) in the repair of congenital lesions is a
more common practice in pediatric cases and as a result issues
such as blood gas management, neurologic injury, and hypo-
thermic injury to the brain are discussed at length. Since pe-
diatric and neonatal cardiopulmonary bypass requires varying
circuit configurations (dependent upon patient size) differences
in bypass circuit components, cannulation, and prime are also
examined.

Extracorporeal membrane oxygenation (ECMO), in both
adult and pediatric application, follows this chapter. This chap-
ter details the pathophysiology of ECMO and the physiology of
the native lung and other major organs during ECMO. Venoar-
terial (VA) and venovenous (VV) ECMO, two different thera-
pies used in treating cardiac and respiratory disease, are also
discussed and compared. Complications can be the determining factor in the survival of many ECMO patients and here the authors stress the prompt recognition and management of these. The later part of the chapter also provides an excellent table for recently published ECMO data and corresponding survival rates.

The final four chapters in this section address CPB support outside the OR, non-cardiovascular applications of CPB, perfusion for thoracic aortic surgery, and port access surgery. Non-cardiovascular applications relate the use of cardiopulmonary bypass for neurologic, urologic, orthopedic, and pulmonary procedures. Liver and lung transplantation, along with unique cases such as accidental hypothermia and anti-neoplastic therapy are included.

Chapter 34, perfusion for the thoracic aortic surgery, includes helpful diagrams on various perfusion setups and cannulation techniques for DHCA. The first edition however, supersedes this chapter by including a discussion of pharmacologic adjuncts, preinduction and anesthetic management, along with techniques of cooling and rewarming. As most of us realize these surgical procedures can be extremely complex and it is the complications that follow, or lack thereof, which ultimately determine the patient outcome. While these issues received noteworthy mention, it would have been appropriate to see some cumulative data regarding patient morbidities and mortalities from several different centers.

In conclusion, the editors of this textbook have done an excellent job of elucidating the new techniques and theories applicable to the practice and management of cardiopulmonary bypass. They have thoroughly delved into the appropriate physiologic considerations behind cardiopulmonary bypass and where appropriate have reiterated concepts pertinent to making sound clinical decisions. Readers can be assured that this text will again serve as a superb resource for all clinicians utilizing cardiopulmonary bypass.