Postoperative Critical Care for Adult Cardiac Surgical Patients

Ali Dabbagh
Fardad Esmailian
Sary Aranki
Editors

Second Edition

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To my wife Samira and to my parents
Ali Dabbagh

To my family: Yvonne, Gabriel and Aaron, and to my parents
Fardad Esmailian

To Nadia, Alex, Heather, and Abla
Sary Aranki

Foreword to the First Edition

Postoperative Critical Care for Cardiac Surgical Patients is a superb amalgamation of a wide variety of clinical expertise in the perioperative and postoperative care of cardiac surgical patients edited by three very fine academicians from three outstanding medical centers and who are in the position of being able to judge the best perioperative and postoperative cardiac surgical care. The three editors have a wide variety of cardiac surgical interest. Dr. Dabbagh is a cardiac anesthesiologist, who is intimately involved in the intraoperative and postoperative care of cardiac surgery patients; Dr. Esmailian is an expert in the care of patients receiving cardiac assist devices and cardiac transplantation, which are some of the most challenging postoperative patients; and Dr. Aranki is an extremely talented surgeon in all aspects of cardiac surgery, especially coronary artery bypass grafting and valve repair and replacement.

This book brings the entire spectrum of cardiac surgical perioperative treatment and postoperative care under one cover. Postoperative critical care in cardiac surgery is extremely important and I believe this book has the potential to be the gold standard in postoperative care for cardiac surgical patients. The key to good surgical results is the combination of an excellent operation and meticulous perioperative and postoperative care, the essence of this book.

The authors are to be complimented for providing up-to-date, accurate, and intellectual contributions for this most important area of cardiac surgery. This book is an excellent effort in advancing the art and science of perioperative and postoperative surgical care.

Boston, MA, USA — Lawrence H. Cohn, M.D.

Foreword to the Second Edition

Postoperative Critical Care for Adult Cardiac Surgical Patients is a successful and succinct guide to this challenging phase of perioperative adult cardiac practice. The three editors from around the world have continued their excellent organized approach to postoperative care in the adult cardiac arena in this second edition. Dr. Ali Dabbagh is a distinguished cardiac anesthesiologist who is an expert in the perioperative care of adult cardiac surgical patients. Dr. Fardad Esmailian is a recognized authority in mechanical circulatory support and heart transplantation that both often have very challenging postoperative care considerations. Dr. Sary Aranki is a renowned and talented cardiac surgeon with special interests in coronary artery bypass grafting, valve repairs, and valve replacements. These three expert editors have combined their expertise and unique perspectives with a select group of contributors to present a comprehensive handbook of adult postoperative cardiac care in 22 chapters.

The second edition has an expanded scope with an additional 11 chapters. The trio of expert editors have taken advantage of this expanded reach to cover in detail additional aspects such as nutrition, safety, economics, transplantation, extracorporeal membrane oxygenation, fluid and acid-base management, infectious and inflammatory complications, as well as organ-based complications in the respiratory, renal, and gastrointestinal systems. This expanded coverage of the specialty has kept the entire spectrum of contemporary postoperative care for the adult cardiac surgical patient under one cover. As Dr. Lawrence Cohn pointed out in his foreword to the first edition, the editors have to be congratulated for developing an excellent postoperative handbook that could become the gold standard in the field.

The essence of excellence in adult cardiac surgery remains the combination of an expert operation with meticulous care throughout the postoperative period. The editors and their selected authors have to be thanked for their combined effort to present the practitioner with a concise and clear approach to postoperative management

of the adult cardiac surgical patient with respect to both the art and the science. The second edition of *Postoperative Critical Care for Adult Cardiac Surgical Patients* advances the quality of care in the field in a significant fashion and will very likely be a valuable bedside reference for all of us.

Philadelphia, PA, USA

Jacob T. Gutsche, M.D., F.A.S.E.
John G. Augoustides, M.D., F.A.S.E., F.A.H.A.

Preface to the Second Edition

As many people especially those working in health care know, a patient undergoes a journey during the perioperative pod; in almost all patients the journey is a stress provoking one, both for the patients and their families. The same happens for cardiac surgical patients undergoing procedures in the operating room or in cardiac catheterization lab, which includes a whole process, not merely an event. Surgery is not, therefore, an end, but rather a "chapter" of the whole process.

Nowadays cardiac procedures rank among the most common type of all procedures, both due to the prevalence of cardiac diseases and improvements in quality of care in this field. At the same time, they are one of the most challenging and most complicated groups of therapeutic modalities, leading to a great and vast field of instructive issues upon students and faculty alike.

Postoperative care plays a crucial role in determining the clinical result for the patient; the success of postoperative care is also directly affected by the quality of the pre- and intraoperative experiences. So, the second edition of *Postoperative Critical Care for Adult Cardiac Surgical Patients* covers the entire postoperative cardiac surgical care, starting from risk assessment models, basic physiologic and pharmacologic knowledge organ based monitoring related to these patients, leading to postoperative clinical care in different major systems; a separate chapter titled "Infectious Diseases and Management After Cardiac Surgery" is added to this part. The next chapters deal with fluid, electrolyte, acid base and pain management and also postoperative considerations related to cardiopulmonary bypass. In this edition, four new chapters complete the book dealing with Postoperative Critical Care in "transplant, ECMO, patient safety, and nutrition." We have to highly appreciate the very impressive and invaluable contribution of all the authors, both in the first and in this edition of the book.

The first edition of this book was welcomed by cardiac surgeons, cardiac anesthesiologists, intensivists, and cardiac intensive care nurses, as well as the students, interns, and residents learning in these environments. Some of the book audiences sent us their fruitful critics regarding potential chapters to be added; the echo of their feedbacks helped us a lot to improve the book and add the new chapters or revise many of the previous ones.

We as the editors would have to acknowledge the very committed and compassionate teamwork of Springer Company, which helped us with the second edition of the book.

And finally, we have to acknowledge our families who have inspired us with accompaniment, empathy, sacrifice, and endless love in such a way that we could promote this effort.

Tehran, Iran — Ali Dabbagh, M.D.
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1 Introduction and History of Postoperative Care for Adult Cardiac Surgical Patients

Mahnoosh Foroughi

Abstract

There is about seven decades that cardiac surgery began to take shape as we know it.

Cardiopulmonary bypass (CPB) is one of the most important advances in medicine and essential milestone of cardiac surgery to maintain tissue oxygenation, myocardial protection, and systemic circulation during cardioplegic cardiac arrest with suspension of ventilatory support. During this period, both CPB machine and protocols have been changed frequently. Despite the steady progress in CPB techniques, it is not a perfect model, and optimal design to reduce its complication is a great challenge.

The concept of critical care unit was first introduced in the late 1950s for life-threatened patients. The progressive technologic advances let the care units as multidisciplinary organization with continuous bedside rather than remote monitoring for old patients with multiple comorbidities who should tolerate the deleterious effects of CPB too.

Keyword

History · Cardiac surgery · Cardiac anesthesia · Postoperative care

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1.1 History of Cardiac Surgery in Brief

In spite of improvement in many fields of surgery, cardiac surgery was absent for long periods due to technical difficulties of this untouchable structure. The heart was recognized as a forbidden area for surgery till 1882, as Theodor Billroth who was the pioneer of abdominal surgery believed any effort to stitch on a heart was equal to losing surgeon's respect between his colleagues. The real need requirements for cardiac surgery were determining of anticoagulant property of heparin, blood types and transfusion, silicone antifoam and development of oxygenator in the early nineteenth century. Indeed, combination of surgery, physiology, and research triggered to create heart-lung machine.

John Gibbon was the pioneer to use heart-lung machine and successfully operated an ASD patient in 1953. Lillehi et al. reported the success of controlled cross-circulation technique in a series of patients in 1955. They cannulated and connected femoral artery and vein of the patient to the donor and used a pump to regulate the rate of flow exchange between them.

During its short existence, cardiopulmonary bypass (CPB) has evolved significantly from the concept of extracorporeal circulation to the present trend of minimal extracorporeal circulation, assist devices, and total artificial hearts. At the begining, the bubble oxygenator was used, but it was changed several times to improve oxygenation, lessen blood element trauma, and have more biocompatible hollow fiber membranous oxygenator. The well-known damaging effects of extracorporeal circulation have been reduced significantly by improvement in CPB techniques.

It has become the standard part of cardiac operation to permit the safe and effective surgical correction of intracardiac disease while maintaining oxygenated blood flow to all other organs. The cardiac operation is a good example of multidisciplinary team working (surgeon, perfusionist, and anesthesiologist) (Stephenson 2008; Braile and Godoy 2012; Punjabi and Taylor 2013; Hessel 2015).

1.2 History of Cardiac Anesthesia in Brief

Over the recent century, accumulative basic knowledge in physiology and pharmacology fields was the foundation for development of cardiac anesthesia. Numerous anesthetic agents have ever been invented and used with extensive range of efficacy and side effects in the history of cardiac anesthesia. Today, it is a safe daily practice for patients undergoing cardiac surgery.

The general anesthetic agents (ether and chloroform) were developed in the middle of the nineteenth century. Inhalational agents were introduced in 1956, morphine anesthesia in 1969, and total intravenous anesthetics in 1989. The concern about safety of anesthetic agents had changed from inflammable effect of ether to bradycardia and hypotension with morphine; prolonged respiratory depression with fentanyl; hypoxia with nitrous oxide; myocardial depression, arrhythmias, and hepatitis with halothane; and prolonged sedation and increased need for inotropic support with thiopentone, and the story has continued.

Historically sucking stab wound in the chest was incompatible with life. In 1899, the effective solution was found by tracheal intubation with intermittent positive pressure ventilation. After the discovery of anticoagulation property of heparin, more experimental studies with CPB had been done. In 1957, systemic hypothermia was introduced to decrease metabolic rate and organ protection during hypoperfusion state of CPB. In 1972, IABP was made as mechanical circulatory tool to support low cardiac output and CPB weaning.

The two most important monitoring instruments for cardiovascular system are pulmonary artery catheter (PAC) and transesophageal echocardiography (TEE). PAC was introduced to measure pulmonary arterial pressure, cardiac output, and systemic vascular resistance in 1979. Currently, PAC is not used routinely and has no important impression on patients' survival in many patients. Also, a considerable number of Central Nervous System monitoring devices have been developed; hoping to decrease potential neurologic drawbacks of the perioperative period with an emphasis on the operation time period. Other sophisticated monitoring devices including but not limited to coagulation pathway monitoring has been incorporated to patient care in adult cardiac surgery.

TEE was introduced in the 1980s and, in contrast to PAC, is the essential part of clinical practice in cardiac operation rooms to monitor diagnosis of cardiac dysfunction and change the plan of operation and reevaluation. It improves outcome after cardiac surgery.

In addition to surgeons, cardiac anesthesiologists should evaluate patients completely before operation to prevent or reduce preventable complications and also, should be involved as a core member of the care provider team throughout the perioperative period (Alexander 2015; Alston et al. 2015; Szelkowski et al. 2015). Also, during the last decades, in many anesthesiology departments, Cardiac Anesthesiology Fellowship programs have been well developed; both for adult and pediatric cardiac anesthesia; targeting improved quality of education and improved patient care.

1.3 History of Postoperative Critical Care for Adult Cardiac Surgical Patients

The concept of critical care unit was first introduced in the late 1950s for life-threatened patients by continuous monitoring of hemodynamic and respiratory parameters at the centralized nursing station.

During the period of experimental studies for CPB, mechanical ventilation, hemodialysis, defibrillation, and pacemaker insertion were designed. Increasing knowledge on cardiovascular physiology aid to measure central venous arterial pressure and cardiac output, and to guide proper treatment as volume repletion and administration of inotropic agents. The engineers and technicians with understanding of life-support biology introduced bedsides rather than remote monitors and measurements to have the ability for appropriate intervention (like electrocardiogram, pulse oximetry, blood gas assessment, end-tidal CO2, chest radiography, near-infrared spectroscopy,

transcranial cerebral oximetry). Today all necessary functions are performed locally at the bedside and independently of the central nursing station associated with computerized patient charting. However, this development could not be substituted by time-consuming medical history taking and accurate physical examination.

The postoperative management in ICU needs to have multidisciplinary team, including cardiac surgeons, anesthesiologists, and nurse specialists for elderly patients with more comorbidity. The major difference with general ICU is the management of patients who undergo CPB that are associated with extensive and predictable physiologic and pathologic sequelae secondary to CPB. The significant changes are due to dilutional anemia, coagulopathy, and systemic inflammatory response.

The most important concerns after cardiac surgery in ICU include bleeding and coagulopathy, the need for mediastinal exploration, mechanical circulatory support, vasoactive medication, arrhythmias, pulmonary complication (prolonged intubation, pneumonia, pulmonary embolism, atelectasis, and pleural effusions), neurologic events (stroke, cognitive disorder), renal injury, thrombocytopenia, and wound infection.

Shortening length of ICU stay is another important issue. Prolonged ICU stay in addition to increase cost and the use of resources, significantly has an important impact on long-term prognosis. Some defined factors are associated with prolonged ICU stay: preoperative anemia, emergency operation, heart failure, neurologic and renal dysfunction, prolonged aortic clamp time, postoperative hyperglycemic state, and type of surgery. There is consensus to decrease intubation time (fast-track) for cardiac surgery patients if the hemodynamic condition is acceptable with minimal use of inotropic agents, no major bleeding, and no neurologic and renal failure (Gullo and Lumb 2009; Parnell and Massey 2009; Szelkowski et al. 2015; Kapadohos et al. 2017; Yapıcı 2017).

1.4 Current Aspects and Future Perspectives of Postoperative Critical Care for Adult Cardiac Surgical Patients

CPB technology has advanced greatly during this century. It permits to have safe cardiac surgery with minimal mortality and morbidity. Such innovative system was not without challenge, as it is effective but not ideal and perfect. This fact leads to discard some accepted policies during this period, many changes were made, and uncertainty about optimal design continues.

The challenge remains to reduce the deleterious side effects to have secure operation. Some of unresolved issues include concern about optimal hematocrit during CPB, temperature management, biocompatibility of surface coating, hemolysis, minimized circuit and venous drainage, pulsatile or continuous flow, pump designs, anticoagulation, bleeding and blood product transfusion, perfect myocardial protection (cardioplegic solution), modifying systemic inflammatory response, minimal invasive cardiac surgery, use of simulation for education, percutaneous valve repair and replacement, total artificial heart, and ventricular assist devices.

Rapid advances in measurement technology field are another attractive and interesting subject, which provide to use less invasive and expensive instruments (such as tissue capnometry) to evaluate hemodynamic condition and differential diagnosis of hypotension and ischemia state during postoperative cardiac surgery (Punjabi and Taylor 2013; Szelkowski et al. 2015; Kapadohos et al. 2017).

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