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# Principles of Miniaturized ExtraCorporeal Circulation



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# Principles of Miniaturized ExtraCorporeal Circulation

From Science and Technology  
to Clinical Practice

 Springer

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*Do not go where the path may lead,  
go instead where there is no path  
and leave a trail.*

*Ralf Emerson*



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## Foreword I

It is a great pleasure for me to write a foreword for a book that concisely addresses a new concept for extracorporeal circulation (ECC). Regardless how we name it – miniaturized, minimized or mini ECC – the principle of less traumatic ECC was successfully translated into clinical practice in the recent 10 years. Perfusion at a constant volume with less blood damage, less haemodilution, reduced postoperative inflammatory response and a lower requirement for intra- and postoperative blood transfusion has been achieved in both adult and paediatric cardiac surgery.

Numerous more or less sufficiently powered studies showed beneficial effects in terms of reduction of myocardial and neurological damage, the number of transfused patients and less inflammatory response. Despite promising results the concept of miniaturized extracorporeal circulation gained only limited worldwide acceptance among cardiac surgeons. Why? As a matter of fact the clinical impact of this novel approach has not been sufficiently addressed, at least in adults, in multicenter randomized controlled trials which would allow a conclusive statement on the clinical benefit. Without sufficient evidence the miniaturized perfusion technique remains a useful and reliable tool only for those who have consequently translated this approach into their own surgical techniques and into perioperative patient management.

One company, MAQUET Cardiopulmonary AG, was the first that caught the concept of minimized ECC and introduced the minimal extracorporeal circulation system (MECC) in 2002 as a closed, compact and fully-coated set of disposables. MECC works with or without a bubble trap or an arterial filter and thus priming volume is as low as 500 mL. Three other companies now offer different miniaturized systems: Medtronic's Resting Heart system, Sorin's Synergy Mini-Bypass and ECC.O systems and Terumo's ROCSafe™ system.

The development of miniaturized ECC systems has not only brought this technology into the operation theatres but also set the path for the consequent development and propagation of mini systems, e.g. MAQUET's CARDIOHELP system at intensive care units, combat grounds and for patient transport with ongoing extracorporeal life support. This development represents a successful continuation of the philosophy of minimizing systemic injury induced by extracorporeal perfusion.

This book was compiled by surgeons and perfusionists who were pioneers in the field of miniaturized ECC. I am quite confident that this book is a valuable source of information for all those who believe in minimal surgery and

also for novices who would like to receive information before they start in the theatre. I wish to thank all my coauthors, my colleagues and, last but not least, my family for their patience to work on this project.

Regensburg, Germany

Alois Philipp, ECCP



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## Foreword II

The foreword by Alois Philipp is an excellent summary of minimally invasive ECC described in this book. MECC is the logical union of ECMO (which began as modified CPB) and full classical CPB (which began as a means to treat massive pulmonary embolism, the ideal ECMO indication). The early success of ECMO was because we eliminated the blood gas interface used for CPB at the time (hence ‘membrane oxygenation’). As ECMO progressed the patients got more complex and support runs got longer (now as long as 2 months), but the inflammatory response that occurs in an hour with CPB does not occur with ECMO. Meanwhile, the inflammatory response to long bypass runs decreased as membrane oxygenators replaced direct gas interface devices during CPB. This prompted us to look for the differences between ECMO and CPB.

It is now clear that air exposure and extreme negative pressure (causing cavitation) are the factors accounting for the difference. The major source of air/blood exposure in CPB is in the reservoir and the cardiotomy suction. Negative pressure (over  $-600$  mmHg) regularly occurs with cardiotomy suction and causes haemolysis. MECC eliminates air exposure, the open venous reservoir and cardiotomy suction; it is essentially ECMO to support cardiac operations. The inflammatory response is minimal, and the incidence of haemolysis and organ failure is much less than conventional CPB. All these factors are well discussed in this book.

Ann Arbor, MI, USA

Robert H. Bartlett, MD, PhD



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## Preface

Minimal ExtraCorporeal Circulation (MECC) systems are used for more than one decade in clinical practice. However, most of the cardiac surgeons and perfusionists do not really know much about them. Despite the excellent clinical results from their use, which are widely dispersed into the literature, and the recent meta-analyses, which show prognostic superiority as well as reduced postoperative morbidity of MECC compared to conventional cardiopulmonary bypass, their penetration in contemporary practice remains low. The main reasons for this oxymoron are the reluctance of the perfusionists to adopt this new technology and the lack of teamwork performance in most cardiac surgical teams. However, MECC requires a learning curve and a more active intraoperative involvement of both the perfusionist and the anaesthesiologist compared to heart surgery with the use of conventional cardiopulmonary bypass. On the other hand, the novel modular systems purge concerns regarding lack of safety when using them. We strongly believe that every cardiac surgical team should at least be familiar with this technology. Moreover, we think it is time to incorporate MECC into scientific guidelines for cardiac surgery.

The aim of this comprehensive textbook is to concisely present the rationale, the principles, the tips, tricks and pitfalls for the use of MECC. This could be the first step towards initiating a training scheme for any cardiac surgical team, and the topics covered in the ten chapters of the book have been thoroughly selected to serve this purpose. We have to sincerely thank the contributors of the book, Bob Bartlett, Alois Philipp, Apostolos Deliopoulos, Adrian Bauer and Frans Waanders who are pioneers in the field. We wish that the readers will find the book useful.

Kyriakos Anastasiadis  
Polychronis Antonitsis  
Helena Argiriadou



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