



Wolfgang Kox and David Bihari (eds.)

Shock and the Adult Respiratory Distress Syndrome

With 89 Figures

Foreword by Iain Ledingham

Springer-Verlag
London Berlin Heidelberg New York
Paris Tokyo

Wolfgang Kox, MD
Senior Lecturer, Department of Anaesthesia, Charing Cross and
Westminster Medical School;
Honorary Consultant Anaesthetist (Director, Intensive Care Unit),
Charing Cross Hospital, Fulham Palace Road,
London W6 8RF, England

David Bihari, MA, MRCP
Lecturer in Medicine, Department of Medicine, The Middlesex Hospital
Medical School, Mortimer Street, London W1P 7PN, England

Cover illustration: Interstitial oedema in a sheep lung 48 hours after
inhalation injury.

ISBN-13: 978-1-4471-1445-1 e-ISBN-13: 978-1-4471-1443-7
DOI: 10.1007/978-1-4471-1443-7

British Library Cataloguing in Publication Data
Shock and the adult respiratory distress syndrome.
1. Respiratory distress syndrome
I. Kox, W. II. Bihari, D.
616.2 RC776.R38

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in other ways, and storage in data banks. Duplication of this publication or parts thereof is only permitted under the provisions of the German Copyright Law of September 9, 1965, in its version of June 24, 1985, and a copyright fee must always be paid. Violations fall under the prosecution act of the German Copyright Law.

© Springer-Verlag Berlin Heidelberg 1988
Softcover reprint of the hardcover 1st edition 1988

The use of registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Product Liability: The publisher can give no guarantee for information about drug dosage and application thereof contained in this book. In every individual case the respective user must check its accuracy by consulting other pharmaceutical literature.

Photosetting by Tradeset, Welwyn Garden City, Herts. AL7 1BH

2128/3916-543210

Foreword

The interrelated syndromes of shock and the adult respiratory distress syndrome (ARDS) continue to attract the attention of both clinical and laboratory scientists. This reflects both the size of the problem and its unresponsiveness to current lines of treatment. Doubtless, a greater appreciation of the underlying pathophysiological disturbances during the past two decades has led to appropriate action and increased survival in the early stages but once established these syndromes have remained remarkably immune to a wide spectrum of therapeutic modalities. This observation stresses the importance of prevention but also indicates the need for continued research into the nature of the established syndromes and the means whereby they may be reversed.

Drs Kox and Bihari are to be congratulated on bringing together within the covers of this volume many of the acknowledged European experts in these two fields of investigation. Each author has provided an up-to-date account of his current experimental and clinical research, and their combined contributions makes fascinating reading. Undoubtedly, these are exciting times in the development of understanding of shock and ARDS. Inevitably, more questions are raised than answers provided, but the accumulated knowledge presented here adds significantly to our understanding of this complex biological jigsaw. From this corporate endeavour will come the clinically useful developments of the future and with them the ultimate hope that the term 'refractory' shock may be finally removed from our vocabulary.

Glasgow
September 1987

Iain Ledingham

Preface

There is no doubt that there have been many advances in the care of the critically ill patient, but the management of septic shock and acute respiratory failure is still fraught with problems. There are as many approaches as there are authorities and considerable controversy remains concerning the support and treatment of patients with these conditions. Although the subjects are frequently discussed at endless international symposia, many clinicians come away with the feeling that they have heard only the prevailing conventional dogma!

For these reasons we thought that it might be useful to invite a small number of workers in this field to participate in a workshop in which their latest research and new ideas could be discussed in a critical atmosphere. Such a workshop took place in Cortina d'Ampezzo, Italy, in March 1986, most kindly sponsored by Fisons PLC, UK. Although there were no proceedings of this meeting, it was generally felt that a number of the contributions and parts of the discussion should be brought together, and these form the basis of this book. Some additional chapters have been included in order to cover more aspects in greater depth. Nevertheless, a publication of this nature can never hope to be definitive but reflects the interests of the editors and their contributors.

It is exactly twenty years since Ashbaugh and Petty introduced the term "acute respiratory distress", which has subsequently become the "adult respiratory distress syndrome" (ARDS), to describe an acute lung injury associated with respiratory failure in adults. Since this landmark in description, and the many publications that have followed, some progress has been made in understanding its pathogenesis and the survival of patients has probably improved. However, not only does the interaction of the various mediator systems require to be clearly defined but the diagnosis of the syndrome also remains somewhat imprecise. Moreover, new methods of primary treatment and ventilatory and cardiovascular support have been introduced yet their clinical role needs further clarification in comparable studies.

The term "ARDS" is as invalid in describing acute respiratory failure as is the label "shock" given to many different forms of acute circulatory failure. Although hypoxaemia and hypotension respectively are clinical markers of the two conditions, the lungs and the circulation probably behave very differently according to the primary insult. Indeed, the two are closely linked for lung damage is one of the manifestations of shock. Why

this should be so remains obscure, but certainly the lungs are the only organ to receive the entire cardiac output and the first to be perfused by the venous effluent from damaged and infected tissue. Beyond the administration of appropriate antimicrobial agents, the management of septic shock and the ensuing respiratory failure is essentially supportive. Yet there is no consensus concerning the best form of ventilatory or cardiovascular support and these issues are addressed in this book.

Best ventilation and cardiovascular support by themselves can only buy time for the patient during which lung healing can occur. The treatment of an acute lung injury includes not only the inhibition and blockade of the various activated mediator cascades brought about by the primary insult but also the prevention of further iatrogenic lung damage. Naturally, arising from the collective description of acute respiratory failure as "ARDS", has been the concept that one particular drug or one form of ventilation might provide a "miracle" cure for this complex condition. This naive view has been supplanted by the belief that only a "cocktail" of inhibitors in combination with different forms of mechanical support tailored for the individual patient will eventually improve the outcome.

Sadly, as is usual when a subject is studied in depth, few answers are found and more questions arise. But in posing the right questions which can lead on to further investigation, we will perhaps have contributed some insight into the pathogenesis and management of septic shock and ARDS.

London
1 January 1987

Wolfgang Kox
David Bihari

Contents

SECTION I: The Morphology and Pathogenesis of Acute Lung Injury

- 1 Fluid Flux Across the Microvascular Endothelium
J. Gamble 3
- 2 The Morphology of the Adult Respiratory Distress Syndrome
G. Schlag and H. Redl 21
- 3 Mediators in Acute Lung Injury: The Whole Body
Inflammatory Response Hypothesis
S. Westaby 33
- 4 Intravascular Microaggregates and Pulmonary Embolization
in Shock and Surgery
C. N. McCollum and K. R. Poskitt 43

SECTION II: Pathophysiology of Septic Shock and the Adult Respiratory Distress Syndrome

- 5 Biochemical Changes in Patients at Risk from the Adult
Respiratory Distress Syndrome: Does the Pancreas Play
a Role?
*M. Lamy, M. E. Faymonville, A. Adam, G. Deby-Dupont,
L. Bodson, P. Damas and P. Franchimont* 67
- 6 Changing Haemodynamic Concepts in Human Septic Shock
L. G. Thijs, A. B. J. Groeneveld and A. J. Schneider 79
- 7 Oxygen Delivery and Consumption in the Critically Ill: Their
Relation to the Development of Multiple Organ Failure
D. Bihari 95
- 8 Right Ventricular Performance and Positive End-Expiratory
Pressure Ventilation
H. Forst, J. Racenberg, K. Peter and K. Messmer 123

SECTION III: Some Aspects of Ventilatory Support

- 9 The Physiological Basis of Ventilatory and Respiratory Support
W. Kox 139
- 10 The Arterial–Alveolar Nitrogen Difference for the Assessment of Ventilation–Perfusion Mismatch
P. Radermacher and K. J. Falke 153
- 11 High-frequency Ventilation: A Step Towards “Compliance-Independent” Ventilation
P. P. Lunkenheimer, W. F. Whimster, N. Stroh, J. Theissen, G. Frieling and H. Van Aken 157
- 12 Extracorporeal Support in Acute Respiratory Failure
L. Gattinoni, A. Pesenti, R. Marcolin, D. Mascheroni, R. Fumagalli, A. Riboni, F. Rossi, F. Scarani, L. Avalli and A. Giuffrida 167

SECTION IV: Some Aspects of Cardiovascular Support

- 13 The Role of Fluid Replacement in Acute Endotoxin Shock
U. Kreimeier, Zh. Yang and K. Messmer 179
- 14 Optimal Use of Vasoactive Agents in Septic Shock
J. L. Vincent 191
- 15 Mechanical Assistance in the Treatment of Shock
C. A. Marshall and W. Kox 197

SECTION V: The Diagnosis and Prognosis of the Adult Respiratory Distress Syndrome

- 16 Prognosis in the Intensive Care Unit: General Principles and Application to Patients with the Adult Respiratory Distress Syndrome
J. R. Le Gall 209
- 17 Adult Respiratory Distress Syndrome: A Scoring System for the Estimation of the Gravity of Pulmonary Disease and Comparison of Patient Populations
P. M. Suter 219
- 18 The Clinical Presentation and Diagnosis of the Adult Respiratory Distress Syndrome
A. Lawson and D. Bihari 225
- Subject Index 235

Contributors

A. Adam

Department of Clinical Biology, Centre Hospitalier de Sainte-Ode,
6970 Baconfoy-Tenneville, Belgium

L. Avalli, MD

Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

D. Bihari, MA, MRCP

Department of Medicine,
The Middlesex Hospital Medical School, Mortimer Street,
London W1P 7PN, UK

L. Bodson, MD

Department of Anaesthesiology and Intensive Care,
University Hospital of Liège, 4000 Liège, Belgium

P. Damas, MD

Department of Anaesthesiology and Intensive Care,
University Hospital of Liège, 4000 Liège, Belgium

G. Deby-Dupont, Lic. Chemistry, Lic. Biochemistry,

Laboratory of Applied Biochemistry,
University Hospital of Liège, 4000 Liège, Belgium

K. J. Falke, MD

Department of Anaesthesiology, University of Düsseldorf,
Moorenstrasse 5, D-4000 Düsseldorf 1,
Federal Republic of Germany

M. E. Faymonville, MD

Department of Anaesthesiology and Intensive Care,
University Hospital of Liège, 4000 Liège, Belgium

H. Forst, MD

Institut für Anästhesiologie, Universität München,
Klinikum Grosshadern, Marchionistrasse 15, D-8000 München 70,
Federal Republic of Germany

P. Franchimont, MD
Laboratory of Radioimmunology,
University Hospital of Liège, 4000 Liège, Belgium

R. Fumagalli, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

J. Gamble, BSc, PhD
Department of Physiology, Charing Cross Hospital,
Fulham Palace Road, London W6 8RF, UK

L. Gattinoni, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

A. Giuffrida, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

A. B. J. Groeneveld, MD
Medical Intensive Care Unit, Free University Hospital,
De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

W. Kox, MD
Department of Anaesthesia,
Charing Cross and Westminster Medical School;
and Charing Cross Hospital, Fulham Palace Road,
London W6 8RF, UK

U. Kreimeier, MD
Department of Experimental Surgery, Surgical Center
University of Heidelberg, Im Neuenheimer Feld 347,
D-6900 Heidelberg, Federal Republic of Germany

M. Lamy, MD
Department of Anaesthesiology and Intensive Care,
University Hospital of Liège, 4000 Liège, Belgium

A. Lawson, MB, BS
Intensive Therapy Unit, The Middlesex Hospital,
Mortimer Street, London W1P 7PN, UK

J. R. Le Gall, MD
Réanimation Médicale, Hôpital Saint-Louis,
1 Avenue Claude-Vellefaux, 751010 Paris, France

P. P. Lunkenheimer, MD
Department of Experimental Thoraco-vascular and Cardiac Surgery,
University of Münster, Domagstrasse 3, 44 Münster,
Federal Republic of Germany

R. Marcolin, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

C. A. Marshall, MB, BS, MRCP
Anaesthetic Department, Guy's Hospital,
St. Thomas Street, London SE1 9RT, UK

D. Mascheroni, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

C. N. McCollum, MB, ChB, MD, FRCS
Department of Surgery,
Charing Cross and Westminster Medical School;
and Charing Cross Hospital, Fulham Palace Road,
London W6 8RF, UK

K. Messmer, MD
Department of Experimental Surgery,
University of Heidelberg, Im Neuenheimer Feld 347,
D-6900 Heidelberg, Federal Republic of Germany

P. Niederer, Pd.
Institut für Biomedizinische Technik der EHT und Universität Zurich,
Moussonstrasse 18, Zurich, Switzerland

A. Pesenti, MD
Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

K. Peter, MD
Institut für Anästhesiologie, Universität München,
Klinikum Grosshadern, Marchionistrasse 15, D-8000 München 70,
Federal Republic of Germany

K. R. Poskitt, MD, FRCS
Department of Surgery, Charing Cross and
Westminster Medical School; and Bristol Royal Infirmary,
Marlborough Street, Bristol BS2 8HW, UK

J. Racenberg, MD
Institut für Anästhesiologie, Universität München,
Klinikum Grosshadern, Marchionistrasse 15, D-8000 München 70,
Federal Republic of Germany

P. Radermacher, MD
Department of Anaesthesiology, University of Düsseldorf,
Moorenstrasse 5, D-4000 Düsseldorf 1, Federal Republic of Germany

H. Redl, PhD

Ludwig Boltzmann Institute for Experimental Traumatology,
Donaueschingenstrasse 13, A-1200 Vienna, Austria

A. Riboni, MD

Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

F. Rossi, MD

Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

F. Scarani, MD

Institute of Anaesthesia, University of Milan,
Via Francesco Sforza 35, 20122 Milan, Italy

G. Schlag, MD

Ludwig Boltzmann Institute for Experimental Traumatology,
Donaueschingenstrasse 13, A-1200 Vienna, Austria

A. J. Schneider, MD

Department of Internal Medicine, Free University Hospital,
De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

N. Stroh, Dipl. Ing.

Institut für Grenzflächen- und Bioverfahrenstechnik der
Fraunhofergesellschaft, Nobelstrasse 12, 7000 Stuttgart 80,
Federal Republic of Germany

P. M. Suter, MD

Division of Surgical Intensive Care, Hôpital Cantonal Universitaire,
CH-1211 Geneva 4, Switzerland

L. G. Thijs, MD

Medical Intensive Care Unit, Free University Hospital,
De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

H. Van Aken, MD

Klinik Für Anaesthesie und Operative Intensivmedizin, Universitätsklinik,
Albert Schweitzer Strasse, 44 Münster, Federal Republic of Germany

J. L. Vincent, MD, PhD

Department of Intensive Care, Erasme Hospital,
Free University of Brussels, Route de Lennik 808,
B-1070 Brussels, Belgium

S. Westaby, BSc, MS, FRCS

Department of Cardiac and Thoracic Surgery,
John Radcliffe Hospital, Headington, Oxford OX3 9DU, UK

W. F. Whimster, MD, FRCP, FRCPath
Department of Morbid Anatomy, King's College Hospital
School of Medicine and Dentistry, University of London,
Denmark Hill, London SE5 9RS, UK

Zh. Yang, MD
Department of Surgery, Tongji Hospital, Tongji Medical University,
Wuhan, People's Republic of China; and Department of Experimental
Surgery, University of Heidelberg, Im Neuenheimer Feld 347,
D-6900 Heidelberg, Federal Republic of Germany