Sepsis, Kidney and Multiple Organ Dysfunction

This book has been made possible by the generous support of Edwards Lifesciences
Proceedings of the Third International Course on Critical Care Nephrology
Vicenza, June 1–4, 2004

Sepsis, Kidney and Multiple Organ Dysfunction

Volume Editors

Claudio Ronco  Vicenza
Rinaldo Bellomo  Melbourne
Alessandra Brendolan  Vicenza

55 figures, 7 in color, and 37 tables, 2004
Claudio Ronco
Department of Nephrology
St. Bortolo Hospital
I-36100 Vicenza (Italy)

Rinaldo Bellomo
Intensive Care Unit
Austin & Repatriation Medical Center
Melbourne, Vic. 3084 (Australia)

Alessandra Brendolan
Department of Nephrology
St. Bortolo Hospital
I-36100 Vicenza (Italy)

Bibliographic Indices. This publication is listed in bibliographic services, including Current Contents® and Index Medicus.

Drug Dosage. The authors and the publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accord with current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new and/or infrequently employed drug.

All rights reserved. No part of this publication may be translated into other languages, reproduced or utilized in any form or by any means electronic or mechanical, including photocopying, recording, microcopying, or by any information storage and retrieval system, without permission in writing from the publisher.

© Copyright 2004 by S. Karger AG, P.O. Box, CH–4009 Basel (Switzerland)
www.karger.com
Printed in Switzerland on acid-free paper by Reinhardt Druck, Basel
ISSN 0302–5144
Contents

IX Preface
Ronco, C. (Vicenza); Bellomo, R. (Melbourne); Brendolan, A. (Vicenza)

Epidemiology and Pathogenesis of ARF, Sepsis and MOF

1 Acute Renal Failure in the Critically Ill: Impact on Morbidity and Mortality
Hoste, E.A. (Gent); Kellum, J.A. (Pittsburgh, Pa.)

12 Acute Renal Failure in the Intensive Care Unit. Risk Factors
Piccinni, P.; Carraro, R.; Ricci, Z. (Vicenza)

19 Pathophysiology of Ischemic Acute Renal Failure. Inflammation, Lung-Kidney Cross-Talk, and Biomarkers
Bonventre, J.V. (Boston, Mass.)

31 Pathophysiology of Sepsis and Multiple Organ Failure: Pro- versus Anti-Inflammatory Aspects
Pinsky, M.R. (Pittsburgh, Pa.)

44 Tropical Acute Renal Failure
Barsoum, R.S. (Cairo)

The Critically Ill Patients: Pathological Mechanisms

53 Mechanisms Underlying Combined Acute Renal Failure and Acute Lung Injury in the Intensive Care Unit
Chien, C.-C.; King, L.S.; Rabb, H. (Baltimore, Md.)
63 Cytokine Single Nucleotide Polymorphism. Role in Acute Renal Failure
Liangos, O.; Balakrishnan, V.S.; Pereira, B.J.G.; Jaber, B.L. (Boston, Mass.)

76 Mechanisms of Immunodysregulation in Sepsis
Cavaillon, J.-M.; Fitting, C.; Adib-Conquy, M. (Paris)

Fluid, Electrolyte and Acid Base

94 Goals of Resuscitation from Circulatory Shock
Pinsky, M.R. (Pittsburgh, Pa.)

105 Intravenous Fluids and Acid-Base Balance
Bellomo, R.; Naka, T.; Baldwin, I. (Melbourne)

119 Glucose Control in the Critically Ill
Schetz, M.; Van den Berghe, G. (Leuven)

132 Dysnatremias in the Critical Care Setting
Moritz, M.L. (Pittsburgh, Pa.); Ayus, J.C. (San Antonio, Tex.)

Pharmacological Issues in ARF and Sepsis

158 Rasburicase Therapy in Acute Hyperuricemic Renal Dysfunction
Ronco, C. (Vicenza); Bellomo, R. (Melbourne); Inguaggiato, P. (Cuneo);
Bonello, M.; Bordoni, V.; Salvatori, G.; D’Intini, V.; Ratanarat, R. (Vicenza)

166 Diuretics in Acute Renal Failure?
Schetz, M. (Leuven)

182 How to Manage Vasopressors in Acute Renal Failure and Septic Shock
Dan, M.; Rossi, S.; Callegarin, L.; Ronco, C. (Vicenza)

Practical Aspects of CRRT

191 Management of Vascular Catheters for Acute Renal Replacement Therapy
D’Intini, V.; Bonello, M.; Salvatori, G.; Ronco, C. (Vicenza)

203 Relationship between Blood Flow, Access Catheter and Circuit Failure during CRRT: A Practical Review
Baldwin, I.; Bellomo, R. (Melbourne)

Renal Replacement Therapy in the ICU: Consensus and Recommendations from ADQI

214 CRRT: Selection of Patients and Starting Criteria
Palevsky, P.M. (Pittsburgh, Pa.)
222 **Fluid Composition for CRRT**  
Leblanc, M. (Montreal)

228 **Anticoagulation for Continuous Renal Replacement Therapy**  
Davenport, A. (London)

   Which Treatment for ARF in ICU?

239 **Peritoneal Dialysis in Acute Renal Failure of Adults: The Under-Utilized Modality**  
Ash, S.R. (West Lafayette, Ind.)

255 **Intermittent Hemodialysis for Acute Renal Failure Patients – An Update**  
Lameire, N.; Van Biesen, W.; Vanholder, R.; Hoste, E. (Gent)

264 **Continuous Renal Replacement Techniques**  
Clark, W.R. (Lawrence, Mass./Indianapolis, Ind.); Ronco, C. (Vicenza)

278 **Hybrid Renal Replacement Therapies for Critically Ill Patients**  
Golper, T.A. (Nashville, Tenn.)

284 **Pediatric Acute Renal Failure: Demographics and Treatment**  
Goldstein, S.L. (Houston, Tex.)

    Technical Aspects of CRRT

291 **Vascular Access for Extracorporeal Renal Replacement Therapy in the Intensive Care Unit**  
Canaud, B.; Formet, C.; Raynal, N.; Amigues, L.; Klouche, K.; Leray-Moragues, H.; Béraud, J.-J. (Montpellier)

308 **Anticoagulation in Continuous Renal Replacement Therapy**  
Vargas Hein, O.; Kox, W.J.; Spies, C. (Berlin)

317 **Replacement and Dialysate Fluids for Patients with Acute Renal Failure Treated by Continuous Veno-Venous Haemofiltration and/or Haemodiafiltration**  
Davenport, A. (London)

    CRRT Information Technology

329 **A Practical Tool for Determining the Adequacy of Renal Replacement Therapy in Acute Renal Failure Patients**  
Pisitkun, T.; Tiranathanagul, K. (Bangkok); Poulin, S.; Bonello, M.; Salvatori, G.; D’Intini, V; Ricci, Z. (Vicenza); Bellomo, R. (Melbourne); Ronco, C. (Vicenza)
New Frontiers in the Management of ARF, MOF and Sepsis

350 How to Approach Sepsis Today?
Vincent, J.-L. (Brussels)

362 High Volume Hemofiltration in Critically Ill Patients: Why, When and How?
Tetta, C. (Bad Homburg); Bellomo, R. (Melbourne);
Kellum, J. (Pittsburgh, Pa.); Ricci, Z. (Vicenza); Pohlmeier, R.;
Passlick-Deetjen, J. (Bad Homburg); Ronco, C. (Vicenza)

376 Coupled Plasma Filtration Adsorption: Rationale, Technical Development and Early Clinical Experience
Brendolan, A.; Ronco, C.; Ricci, Z.; Bondoni, V.; Bonello, M.;
D’Intini, V. (Vicenza); Wratten, M.L. (Mirandola); Bellomo, R. (Melbourne)

387 Plasmapheresis in Sepsis
Berlot, G. (Trieste); Di Capua, G. (Naples); Nosella, P.; Rocconi, S.;
Thomann, C. (Trieste)

395 Author Index

396 Subject Index
Multiple epidemiological studies have established and continue to emphasize the fact that sepsis is the dominant syndrome in modern Intensive Care Units. Severe sepsis occurs in approximately 50 to 100 cases/100,000 people/year and is the most common cause of death in intensive care patients. Severe sepsis and septic shock are now also the most common cause of kidney failure in intensive care and the most common cause of severe kidney failure requiring in general renal replacement therapy. This kind of kidney failure, however, is rarely seen in isolation. Most commonly, it occurs as part of a syndrome of multiple organ failure, where the kidney is one of several organ systems that become profoundly dysfunctional. In this setting, vasodilatory shock is frequent, mechanical ventilation is frequent and disorders of bone marrow function, acid-base balance, gastrointestinal activity and cerebral function are common. Thus, severe sepsis links kidney function, multiple organ function and patient outcome from the start to the end.

The care of patients with severe sepsis and/or septic shock is complex and typically involves a multidisciplinary approach. Critical care specialists typically co-ordinate resuscitation, fluid administration, and mechanical ventilation. In conjunction with the nephrologist, they deal with issues of electrolyte and water balance, acid-base control and renal support. Increasingly, renal support focuses on complex approaches to extracorporeal therapy, which require the use of sorbents, high-volume plasma water exchange techniques and plasmapheresis or plasma exchange techniques. In conjunction with the infectious disease specialist, critical care physicians and nephrologists co-ordinate antibiotic or antifungal treatment. This requires important adjustments, which
depend on renal function and the technique of renal support being applied. Accordingly, knowledge of pharmacokinetics and pharmacodynamics becomes essential. Finally, emerging evidence indicates that the resolution of the septic state and of multiorgan dysfunction might require optimization of the endocrine environment through replacement of glucocorticoids in patients with loss of adrenal functional reserve, the supplementation of vasopressin in selected patients with vasodilatory shock and, perhaps more importantly, the restoration of normoglycemia through aggressive insulin administration.

The above considerations make it clear that for patients to receive optimal care, the treating physician needs a detailed working knowledge of multiple aspects of care so that appropriate multidisciplinary assistance is sought at the right time and new techniques of organ support are applied in a safe, timely and effective way. In the present book we have combined the contributions of experts in various fields to tackle some of the fundamental and complex aspects of patients care. First we have focussed on the epidemiology of acute renal failure in intensive care and on its role in determining outcome. We then present recent advances in the insight into the pathogenesis of ischemic renal failure and of sepsis and multiple organ failure. Because the immune response to infection is central in determining organ injury, the book then focuses on its role in determining renal and lung injury, on the role of immune mediators in inducing dysregulation of the immune response and on the role of genetics in determining such a response. We then move to the issue of fluid resuscitation, the goals of resuscitation, the importance of acid-base control and the issues that surround glucose control and sodium control in the ICU. Pharmacological aspects of care involving the use of common medications such as diuretics and vasopressors are analyzed and the possible role of uric acid modulation discussed. As extracorporeal therapies are being increasingly used in the care of these complex patients, we focus on important technical aspects of such therapies including vascular catheter management, control of circuit blood flow, anticoagulation, choice of replacement or dialysate fluids, the role of information technology and the selection of patients for treatment. As the choice of treatment modality remains controversial, we also discuss different approaches to renal support from intermittent dialysis to continuous therapies and hybrid techniques. Finally, we conclude with a description of advanced extracorporeal techniques of organ support and discuss their role in the management of sepsis and kidney failure in the context of an overall strategy of sepsis management.

The aim of this book is to present all physicians involved in the care of critically ill patients with sepsis and kidney/multiorgan dysfunction with a practical and up-to-date summary of current knowledge and technology as well as a fundamental understanding of pathogenesis and likely future developments in this field. Our endeavour is part of a now long-standing and continuing effort
to improve patient outcome through laboratory and clinical research, education and consensus development. Working on the development of the specialty of Critical Care Nephrology and of the Acute Dialysis Quality Initiative (ADQI), we hope to move steadily in the direction of improved outcomes for critically patients with kidney and multiorgan dysfunction.

We hope this book will serve as a useful tool for consultation, reference and informative reading for all professionals involved in the care of critically ill patients and that it will represent yet another small step toward improving the standards of care for such patients worldwide.

Claudio Ronco
Rinaldo Bellomo
Alessandra Brendolan