REPLACEMENT OF RENAL FUNCTION BY DIALYSIS

edited by

WILLIAM DRUKKER, FRANK M. PARSONS,
JOHN F. MAHER

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FOREWORD

BELDING H. SCRIBNER

The year was 1942 and Willem Kolff was hard at work perfecting the device that would not only revolutionize the treatment of renal failure, but more importantly point the way to the development of the entire field of extracorporeal devices in general and cardiac bypass devices in particular.

The enormity of the impact that Kolff's contribution was to have on medicine was revealed retrospectively to me when I recalled that in that same year, 1942, I was a second year medical student at Stanford University, taking among other things, P.J. Hanzlik's required course in pharmacology. I have two memories of that course. One was the requirement that we students learn to recognize 64 old time drugs by appearance, smell and taste. For better or worse, almost all of the 64 have disappeared from the scene. The other memory is the more pertinent one. I can still visualize the scene in the small classroom in the attic of the old red brick Stanford Lane building at Webster and Sacramento Streets. Professor Hanzlik had a pigeon for a "patient" and had planned a dramatic demonstration. I can still hear him command one of my fellow students to "Seize the patient!", which the student did in fear and uncertainty as the poor bird struggled against its fate. Hanzlik then proceeded with great flair and ceremony to inject some drug intended for intravenous use into the poor pigeon, where upon the bird promptly expired and Hanzlik drove home the point that intravenous therapy of any kind was dangerous and should be avoided at all costs. This "conservative" attitude was quite consistent with that prevailing throughout the practice of medicine in that era. If intravenous therapy was dangerous, then a device for extracorporeal circulation must be an invention of the devil! Indeed, for the decade after the first clinical dialyses in Europe and Canada, acceptance was painfully slow and often resisted by all the usual techniques of those in power. During the early 60's, we encountered exactly the same kind of resistance to the concept of chronic dialysis. But as has happened over and over again in all of science, the heresy of one decade becomes the practice of the next – a phenomenon that the young heretics among the third generation readers of this volume should not forget.

And so, today Drukker, Parsons and Maher have successfully undertaken the very difficult task of bringing together in one volume all the diverse elements of dialysis therapy. The size of the volume reflects not only the magnitude of the interdisciplinary effort that brought about the technical and clinical advances, but also the many clinical and other ramifications of dialysis therapy.

In 1977, this therapy will cost the United States taxpayer nearly one billion dollars as the number of dialysis patients in the United States soars above 30,000, while the projection of the ultimate number increases from 40,000 to 60,000 and the cost projection to two billion per year by 1985. Concurrently, in the United States, the percentage of patients on home dialysis has dropped from a high of 41% in 1973 to just under 15%. This trend away from home dialysis cost the United States taxpayer an additional 150 million dollars in 1976. In an effort to control costs, the United Kingdom has increased the percentage of patients on home care to nearly 70%. In addition, the United Kingdom and perhaps other Western countries are beginning to exert subtle but effective cost control on dialyses by limiting the numbers of dialysis patients (1). In contrast, in the United States in 1977, there is no cost control on dialysis. What this contrast means to me is that dialysis is having an impact on Western medicine far beyond its significant impact on the patients, family physicians and staff who are directly involved.

The nature and enormity of this impact began to become apparent to me in 1962 when magazine

writer Shana Alexander came to Seattle to do a story on the artificial kidney. I shall always remember how incredulous I was that she did not want to see or hear about the patients whose lives had been saved – no interest there. She wanted to find out all about the "life and death committee". As a result, her article on the Seattle Life and Death Committee appeared in *Life Magazine* that fall (2) and set off discussion and controversy that have persisted to the present (3); indeed, the current British versus American approach to chronic dialysis is but a dramatic extension to international medicine of the basic "who shall live" issue that was raised by the Seattle Life and Death Committee. I believe that what has happened is that dialysis has greatly accelerated the process of bringing to the forefront a basic issue in Western medicine that up to now has been kept hidden. That issue is *priorities*. Can the United States really afford to spend two billion dollars per year on dialysis? If not, who will decide to curtail expenses, and how will the decision be implemented? Significant curtailment already is being implemented in the United Kingdom by limiting the dialysis population (1). The question is how are they able to "get away with it", and if the real truth were known, could they get away with it?

To put this issue in a different context, I believe the rapid development of dialysis marks the beginning of the end for unrestrained expansion of expensive medical technology – just as surely as the energy crisis tells us that unlimited expansion of a petroleum based Western civilization is about to come to an end. I believe that the energy crisis poses the greatest threat to democracy that has ever been posed in peacetime because the basic inability of the democratic process to cope with decisions about priorities in times of crises. Does dialysis and other very expensive technology pose a similar threat to medical free enterprise as still practiced mainly in the United States? Unless we put our house in order, I believe it does.

Let us take a brief look at another example of costly medical technology that already has overtaken dialysis in terms of total cost. Coronary by-pass surgery is currently costing Americans nearly two billion dollars per year. Preston, in a just published critique of the operation (4), points out that not only is its efficacy unproven, but he makes a strong case for the point that the economic incentives of the free enterprise system rather than medical efficacy explain why in 1975 the operation was performed on 28 patients/100,000 population in the United States in contrast to 2.1 patients/100,000 population in Western Europe.

Dialysis doctors can take comfort in the fact that at least the question of efficacy is not an issue with our expensive technology. But important and unresolved issues nag at our conscience with respect to the cost-benefit ratio of dialysis. These issues are far too complex to be resolved during the life-time of the first generation of readers of this volume and pose the ultimate challenge to the younger generations. The clinical and technological aspects of dialysis must not remain static at the state of the art level described in this volume while the demand for costly services increases. Rather, we must build on the knowledge reviewed in this book to improve the cost-benefit ratio of our services. Meanwhile, we function as our technological advances create new social problems. And so my advice to all three generations is to try and understand and cope with a new responsibility that dialysis, because of its high cost, has introduced into the basic doctor-patient relationship. How can each of us fulfill our basic responsibility to our patients while at the same time doing everything possible to reduce the overall cost to society of this very expensive treatment?

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PREFACE

Some 50 years after Haas' first human dialysis, and 35 years after Kolff's pioneering work, a book on the present state of the art cannot be written by one person: obviously it had to be a multi-authored volume. Therefore some overlap between chapters and even a few controversies between authors became unavoidable.

However we deliberately avoided editorial streamlining of manuscripts, leaving the authors' personal style and personal opinions unaltered as much as possible. This may make the book more vivid to read and may sometimes stimulate readers to study a subject in greater detail from the literature. Additionally, both British and American spellings have been kept because of the international nature of the book. To preserve space, though, the index uses only American spelling.

The editors wish to express their sincere thanks to so many distinguished colleagues who contributed by writing one or more chapters.

Our gratitude goes also to Dr. Belding H. Scribner for writing the Foreword and to Drs. Jonas Bergström and Peter Fürst for giving us permission to use one of their "Peak 7C" diagrams for the hard cover of the book as a symbol of uraemic toxins that should be removed by dialysis and related techniques. The editors have been most fortunate to obtain the assistance and guidance of Mr. Boudewijn F. Commandeur and Miss Lynn Bacon, of Martinus Nijhoff's Medical Division, who introduced us to the complicated field of international publishing and technology of modern typesetting and printing.

Without the patience and devotion of our secretaries (Amsterdam: Mrs. Mabel Mary Drukker-Lely; Leeds: Miss Linda A. White; Farmington, CT: Miss Arlene Lavilette), who apparently never felt tired, and the patience and tolerance of our families, the book would not have been born.

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TABLE OF CONTENTS

1

INTRODUCTION

The fate of the patient in irreversible terminal renal failure has dramatically changed in less than two decades.

Little more than 15 years ago, if unresponsive to manipulations that sometimes restore renal function, the patient in terminal renal failure had no alternative than to face death by uraemia. His relatives and his physician had to sit down at his bedside in frustration.

Much of the mental and physical suffering that characterized progressive and finally terminal renal failure as it led slowly to the end of life has nearly disappeared from our hospital wards. Currently, it is even difficult to expose our medical students to the clinical syndrome called uraemia and to teach them at the bedside the signs and symptoms of the end stage failing kidneys.

Newly acquired knowledge gained by the efforts of research scientists is rapidly accepted and absorbed by mankind. Panta rei: nothing is static, everything changes. Surprising and exciting medical progress of yesterday belongs today to the common daily medical practice. Fifteen years ago, the patient in terminal renal failure and his relatives asked: "Is there any chance of survival? Could my life be saved with dialysis? Is there any chance to survive with a transplant?" Today the preterminal renal failure patient quietly asks his physician when he will start his chronic dialysis treatment which nowadays usually begins long before the patient has the onset of symptoms of uraemia. But the second question is often: "And what about holidays? What about travelling, swimming, camping or skiing when I am on that machine?" Presently, because of the availability of portable and sophisticated dialysis machinery, not only are rehabilitation, gainful employment and leisure activities achieved, but also travelling for holidays or business purposes is possible for maintenance dialysis patients. Further miniaturisation and the development of a wearable artificial kidney system are within the horizon.

However, the treatment of the patient in terminal renal failure can be complicated and difficult and an enormous and still fast growing literature about the technology and pathobiology of dialysis therapy has developed and is scattered over many journals, transactions, proceedings, monographs and manuals. The first generation nephrologists and internists, some of whom somewhat hesitatingly and even with some reluctance entered the field of replacement of renal function, started more or less from scratch and saw their knowledge grow. They could readily keep up with the modest volume of dialysis literature and learned from each other at meetings, symposia and congresses. It was like a large family of enthusiastic, energetic physicians working in a new and fascinating field of medicine. However, the first generation is gradually approaching the end of their careers and is already joined by a second generation. The third generation of young physicians who are to enter the field is already knocking at the door. They face an abundant, often bewildering and widely scattered literature on dialysis and treatment of terminal renal failure in general. It can be difficult, even frustrating for the novice in the field to sort out what is important from the past, what is useful at present and what should be disregarded in between. Unless one is especially gifted with mathematical and physical knowledge, it can be a difficult, even awesome or frightening task to assimilate the information in the treatises of physics of modern dialysers, the complicated electronics and hydraulics of modern monitoring and proportioning systems and the physics of sorbent and ion exchange regeneration systems for dialysis fluid. Therefore, a book offering an encyclopaedic review of the present state of the art seems to be useful. The contributors to this text include many of the pioneers who laid the foundation for this discipline and others who contributed importantly to its rapid growth. Those who are presently newly entering the field may find this book a useful guide

for the present treatment of the patient in terminal renal failure by haemodialysis or peritoneal dialysis and they will also find descriptions of the conservative methods of treatment which necessarily accompany dialysis treatment. Others, even that first generation of dialysis physicians and scientists may find the book useful as a reference guide. Accordingly, we have attempted to offer in this manual full information and an extensive but critical review of the present concepts underlying this therapy. We have deemphasised or totally omitted, however, relatively unimportant details, outdated facts and descriptions of archaic techniques and machines.

Dialysis interposes a semipermeable membrane between a flowing stream of blood and an appropriate rinsing solution. By convective and diffusive transport, the composition of body fluids approaches that of the dialysis solution. Simultaneous ultrafiltration decreases body fluid volumes, presumably toward normal. Lower concentrations of toxic solutes in body fluids are generally associated with clinical improvement of the uraemic syndrome and hypertension and congestive heart failure usually recede as volume excess is corrected. But, as we cannot identify precisely and understand sufficiently the toxicity of the retained solutes, we deplete indiscriminately, removing useful as well as toxic solutes and in proportions dictated by membrane permeability or sorbent affinity rather than according to their toxic potential. Further, we substitute poorly for the endocrine and metabolic aspects of renal regulation of body composition. Our therapy is a dramatic success compared to the natural history of progressive renal disease, but is cumbersome, awkward and inefficient compared to the healthy kidney.

Following the initial successful dialysis for therapy of renal failure, numerous modifications in dialyser design and technique and in other aspects of therapy soon followed, improving the efficacy of therapy. It now appears that additional major improvements in therapy may await increased fundamental knowledge. Accordingly, the complete reference work must review the basic concepts of mass transport, extracorporeal thrombogenesis, biochemical and metabolic abnormalities, organ pathophysiology and so forth, as well as present the pragmatic information of why, when and how to dialyse patients. We have striven for a balance of such practical and fundamental information.

Undoubtedly, segments of this book run the risk of rapidly becoming out of date. The science of the pathophysiology of terminal renal failure and the technology of its treatment are still in a stage of dynamic progress; our knowledge in this field is far from petrified. While we have tried to be as current as possible, we have avoided, where appropriate overemphasis on the current vogue or the dated hypothesis.

As the written word often stimulates criticism, even more than the oral presentation of facts or hypotheses, the authors and editors are open for readers' criticisms and opinions. Recalling that sharing our clinical and investigative experiences helped our knowledge grow and remain current, we anticipate that such a dialogue will be helpful.

All generations of clinical nephrologists from the first to the third and those that follow, should be aware of the enormous responsibility for the quality of treatment offered to the terminal renal failure patient who puts his life in their hands, having virtually no other choice for survival. The quality of treatment depends on the dedication and the knowledge, training and professional skill of the physicians, their nurses and paramedical co-workers. We should never forget that a bad treatment often offers a long period of disability, of misery and suffering if not death. We now are not only capable of saving thousands of lives, but we are also able to attain the goal of offering those patients in terminal renal failure and their families a good and enjoyable quality of life.

May this book contribute to the goal of improved treatment for those in terminal renal failure.

THE EDITORS