Handbook of Diabetes Technology

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ISBN 978-3-319-98118-5 ISBN 978-3-319-98119-2 (eBook)
https://doi.org/10.1007/978-3-319-98119-2

Library of Congress Control Number: 2018967707

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

It is very fitting that this timely book on diabetes technology should be written by a group of experts from France, since a paper by authors from that country published 44 years ago was highly influential in efforts to improve diabetes management, and in many ways was the beginning of what one might call the 'modern era' of technology in diabetes care. In 1974, French colleagues showed that up to 5 days of intravenous infusion of regular insulin from a pump held in a shoulder bag and given at a slow basal rate, augmented at meals, could achieve near-normoglycaemia in a small group of people with type 1 diabetes (Slama G et al. Diabetes. 1974;23:732–7). For the first time we saw that prolonged infusions of insulin are feasible and produce good glycaemic control without feedback control; and it suggested, at least to some, that portable pumps might be a technology for achieving strict glycaemic control in everyday clinical practice.

Building on these ideas over the next couple of years, continuous subcutaneous was substituted for continuous intravenous infusion in order to avoid the potential long-term problems of the intravenous route, the pump became a little smaller and 'insulin pump therapy', as it is now usually known, was introduced (from 1976), at first as an experimental treatment and then as an effective treatment option for type 1 diabetes. It is now used by more than one million people around the world with diabetes, so from this device alone one can say that technology forms a large part of current diabetes care.

These few years in the late 1970s and early 1980s saw the start of three other first-generation diabetes technologies that are now in common use, though in much more sophisticated versions: self-monitoring of blood glucose using portable meters and reagent strips in 1978, insulin 'pens' in 1981 and continuous glucose monitoring using an implanted electrochemical sensor in 1982. Since those early days, diabetes technology has taken more years to reach clinical maturity than many would have anticipated and liked, and faces some notable challenges even now. Foremost amongst these are variable and limited access for many of the patients who would benefit, and less than optimal use of some technologies like insulin pumps, as reflected in widely varying clinical outcomes in trials and in clinical practice.

One of the first things I was taught as a young doctor starting in diabetes research and clinical practice was that the biggest problem we face is putting into practice what we already know. Poor dissemination of information, lack of resources and lack of relevant practical skills have always hindered uptake of new treatments. But

technology probably plays a larger part in the care of diabetes than any other chronic disease, and this is surely set to continue, with increasing opportunities for automatic control of blood glucose (the 'artificial pancreas'), mobile connectivity and artificial intelligence. It has never been more important for diabetologists to know the best modern evidence for the effectiveness of technology, to understand which patients are best and most cost-effectively treated, and to appreciate both the advantages and the disadvantages of these new devices.

This book comprehensively addresses these issues and delves into much more besides: it summarises information on those diabetes technologies that are already in common and routine practice and those that are emerging—including external and implantable pumps, syringes and insulin pens, glucose meters, continuous glucose monitoring and closed-loop systems, the cell-based technology of islet cell transplantation, computer and software aids to education, data analysis, data logging, and decision support, mobile telephone apps, videogames and telemedicine.

It is a pleasure then to introduce this Handbook of Diabetes Technology and the chapters that follow. I am sure it will be of real practical help to very many healthcare professionals and students of diabetes. It is a substantial contribution to the understanding and successful application of technology in diabetes and thus to improving the care of people suffering from this condition.

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Preface

A comprehensive handbook browsing available resources related to diabetes technologies: glucose monitoring, devices for treating diabetes, telemedicine, software's and videogames! A helpful tool for physicians and nurses involved in the management of diabetes!

Caen, France — Yves Reznik

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About the Editor

Yves Reznik, MD is a Professor of Endocrinology, Diabetes and Metabolic Diseases at Caen University, Normandie, France. He is involved in the field of Diabetes Technologies and has an extensive experience with the management of insulin pump in type 2 diabetes. His team is involved in French and European closed-loop programs in type 1 and type 2 diabetes.

About the Authors

Pierre Y. Benhamou, MD, PhD Professor of Endocrinology, Head of the Department of Endocrinology, Diabetes and Nutrition, University Hospital, Grenoble, France. He graduated from Grenoble University in 1988, and gained fellowship and completed a 3-year research at UCLA in 1991. He is founder and head of the Swiss–French clinical research network (GRAGIL network) devoted to pancreatic islet transplantation since 1998. He is also founder and head of the Telemedicine and Advanced Technology Study Group of the Societe Francophone du Diabete since 2005. He authored and coauthored more than 130 scientific papers referenced in the MedLine database. He has a vast experience in multicentric clinical research in the field of diabetes and was principal investigator of several trials. He conducted two nationwide trials that demonstrated the efficiency of pancreatic islet transplantation for the management of brittle type 1 diabetes (Gragil and Trimeco Trials) and is currently conducting a medico-economic study in this field (Stabilot Trial). He is also a coinvestigator in a European project aiming at designing a bioartificial pancreas, in collaboration with CEA (Biocapan Project). He promotes the use of telemedical solutions aiming at improving metabolic results and quality of care of diabetic patients. In the past 5 years, he was investigator in three large multicentric trials testing such solutions. He also is investigator in the DIABELOOP project aiming at creating an artificial pancreas connecting a glucose sensor and an insulin pump.

Michael Joubert, MD, PhD holds a Chair of Professor of Endocrinology, Diabetes and Metabolic Disease at the Medical School of the University of Caen, France, and is Head of the Clinical Research Center of Caen University Hospital. He is involved in diabetes technology through clinical studies and implementation of these technologic tools and procedures in everyday routine medical practice.

Sandrine Lablanche, MD, PhD is assistant professor of Endocrinology, Diabetology and Metabolic diseases at Grenoble Alpes University, France. She is involved in the field of diabetes technologies and has developed expertise in the treatment of patients with brittle type 1 diabetes and in islet transplantation. She is a member of the GRAGIL network.

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Schaepelynck focuses on the management of diabetic patients treated with an external or implanted insulin pump, but is also involved in continuous glucose monitoring systems.

Schaepelynck was president of the EVADIAC group from 2012 to 2015 and her areas of interest involve all new technologies applied to diabetes.

Emmanuel Sonnet is hospital practitioner at the University Hospital of Brest (France) and qualified specialist in diabetology and endocrinology. He first studied and worked at the University of Rennes (France). His experience, area of interest, and recognized expertise are in the domain of the insulin pump therapy and new technologies in e-health (especially m-health).

Introduction to Diabetes Technologies

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Pierre Yves Benhamou

For almost a century, diabetes mellitus has been at the crossroads of various technological innovations. The discovery of insulin (1922) was actually initiating the first therapeutic use of an extracted natural hormone, and this breakthrough was later followed by the first radioimmunological assay for the measurement of a circulating hormone (1960) and then by the first recombinant hormone ever produced (1978). These achievements led to several Nobel Prizes. Interestingly, all these biochemical innovations were later applied to other areas of medicine but were initially designed for the cure of diabetes. This first era of diabetes research ran from the 1920s to the 1970s and can be summarized as the "childhood years" where most of the pathophysiological and therapeutic basic concepts were described and established.

The second era, covering the 1980s to the early 2000s, introduced therapeutic concepts and tools that are still valid and explored nowadays: glucose self-monitoring, portable insulin pumps and implantable pumps, and insulin injection devices, all these landmarks were launched during this period. This is also true for other therapeutic breakthroughs, ranging from therapeutic education to cell therapy using islet transplantation or bioartificial pancreas. HbA1c was introduced in the 1980s, whereas the 1990s provided the first insulin analogs with pharmacokinetic properties that were more adapted to the therapeutic purpose. This era ended in 2000 with the introduction of the first continuous glucose monitoring system and the report of the first successful islet transplantation series. Yet these "teenage years," although astonishing by this firework of remarkable technological innovations that, overall, contributed to a significant improvement of diabetes care quality, failed to relieve patients from the daily burden of the disease.

We now stand in the third and hopefully last era. The "adulthood years" look as if history was speeding up its pace toward a cure. Continuous glucose monitoring without finger pricks is a reality. Closed-loop insulin delivery is expected to be

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Y. Reznik (ed.), *Handbook of Diabetes Technology*,
https://doi.org/10.1007/978-3-319-98119-2_1