



## INTRODUCTION

This is the second edition of *Insulin Pumps and Continuous Glucose Monitoring: A User's Guide to Effective Diabetes Management*. It was imperative that we update this book because the field of diabetes technology has advanced so rapidly over the last 3 years. There have been so many enhancements to insulin pump therapy since the first insulin pump in the early 1980s. The first pump was jokingly referred to as the “big blue brick,” and it weighed several pounds. The insulin-filled syringe was on the outside of the pump, the pump used a butterfly needle (the needle commonly used for intravenous delivery of medications) placed in the subcutaneous tissue, and, for the most part, it could only be used in the hospital setting. However, despite its many drawbacks, most felt the pump was a great advancement for patients, who benefitted from the continuous delivery of basal insulin and from the intermittent boluses that were given to match their food intake and to correct an abnormal blood glucose level when indicated. Over the ensuing 30 years, we have all witnessed incredible advances in the understanding of what happens to the cells of the body as the result of the diabetes process. We have seen tremendous breakthroughs in diabetes drug discovery, including the development of a myriad of insulin analogs, some now coupled with other injectable and oral medications, and rapid advances in glucose monitoring technology. We have determined better ways to deliver diabetes education and support, and we continue to combat discrimination against people with diabetes. And most importantly for this book, today we have insulin pumps that are small, fast, and smart, and we have continuous glucose

monitors (CGMs). CGMs can give information retrospectively or in real time to help with diabetes management decisions. CGM data can be transmitted to secondary screens through the cloud so the patients can view their own data more discreetly or send it to a family member or care provider in real time for additional help. In some devices, the pump and the CGM work together in a single system.

These integrated systems have allowed for the CGM to stop insulin delivery at either a preset or at a predicted low glucose threshold. “Artificial pancreas” systems that automate insulin delivery have been evaluated in a series of clinical trials, and a hybrid version is now approved for commercial release for people with diabetes.

When you or your child were diagnosed with diabetes, you might have felt that you embarked on a new, different life journey. To succeed on that journey, you need to effectively manage your diabetes so that the maximal amount of time is spent with glucose levels in the target range, and the minimum amount of time is spent in the low or high range. To accomplish this, you, with the help of your family and friends, must track glucose levels to be able to deliver insulin in a manner that closely resembles how your body produced and used insulin before you were diagnosed. Often, the best way to achieve this is to use an insulin pump. This step is now increasingly accompanied by using a CGM, either as a stand-alone device or integrated with the insulin pump. Integrated systems now allow for automation of insulin delivery and serve as the platform for the artificial pancreas. These technologies—although not really that much more complicated than your smartphone, computer with continually updated systems, or computerized, connected home devices—do require basic understanding, training, and follow-up adjustment to help improve diabetes outcomes.

The purpose of this book is to give you practical tips, including the knowledge and the skills to optimize insulin pump therapy and continuous glucose monitoring, if that is what you and your health care provider decide is best for you or your child. This book will walk you through everything from choosing the right pump or CGM for you, to how to download and review your settings and how to use your pump and/or CGM for effective diabetes care through

daily activities, travel, school, or college. The future of pumps and CGM technology in diabetes care is also addressed. If you already have an insulin pump and feel confident with basal rates and bolus settings, you might want to review Section 2, *The Nitty-Gritty about Pumps*, and focus your attention on sections 3 and 4. If you are looking for information about CGMs, focus your attention on Section 3, *Uploads, GGM, and Closing the Loop*. The goal is to enable you to make your journey through life with diabetes as successful and as free from short- and long-term complications, and with as minimal burden, as possible.

### **SECTION 1: THE BASICS**

The goal of Section 1 is to review the basic physiology of glucose control and what occurs when someone has diabetes. To understand what you are striving for, you must also be aware of glucose and A1C targets. The central principles of how diabetes is now managed are supported by a series of important research studies. The critical ones, such as the Diabetes Control and Complications Trial (DCCT) and important research studies concerning insulin pumps, CGMs, and integrated sensor-augmented pumps, with or without automated features, are reviewed so that you understand the evidence surrounding the recommendations for meticulous diabetes control.

The insulin pump is a small mechanical device worn by someone who has diabetes and who is treated with insulin. The insulin pump helps facilitate diabetes control and lifestyle flexibility. Insulin enters the body from the pump either after flowing down the tubing into a small cannula (a soft tube) or a small needle placed under the skin, or through “tubeless” pumps placed straight onto the body with a small needle automatically inserted. Most people with type 1 diabetes and many with type 2 diabetes who require intensive insulin therapy use basal-bolus regimens, and the benefits of basal-bolus therapy will be outlined. In addition, you will see how you can balance insulin administration, food, and activity with greater ease while using an insulin pump. The importance of glucose monitoring with blood glucose meters or CGM systems will be stressed. The

importance of having glucose data, seeing patterns and trends, and using alerts and alarms will be explained as a way to facilitate diabetes management.

## **SECTION 2: THE NITTY-GRITTY ABOUT PUMPS**

Section 2 gets into the practical aspects of insulin pump therapy. The components and features of the pump are described, emphasizing the pump's bolus calculator and many other advanced features, perhaps the most important of which is calculating something called insulin on board (IOB), or active insulin. Sections on both basal and bolus insulin delivery cover all aspects, from determining your initial pump settings to how to adjust settings over time. As you read through this section, it should become obvious that adjustment of the regimen is required throughout your diabetes journey, since factors such as growth, weight, activity, stress, and lifestyle habits change over time. Because food is a critical element in diabetes management, there is a detailed discussion of carbohydrates, protein, and fat; understanding how to read food labels; and ways to assess your portions. One of the true challenges in diabetes management is adjusting insulin and carbohydrate intake for planned and unplanned physical activity. To succeed with insulin pump therapy, it is critical to understand infusion sets, how they differ, and what you need to consider in making the decision about which set you want to use. An in-depth review of principles to manage exercise is given in this section.

## **SECTION 3: UPLOADS, CGM, AND CLOSING THE LOOP**

Section 3 will help you understand how important it is to upload data from pumps and CGMs. These uploads can be used to help you understand your patterns and trends and also to make adjustments in your therapies. The basics of CGM will be described, including its components, how the interstitial glucose compares to the blood glucose, and how to use CGM to improve your diabetes outcomes. Having glucose values displayed continuously and the ability to see trends in glucose levels can help you avoid serious highs and lows. The latest advance in commercially available technology, the hybrid

closed-loop system, will be discussed so that you understand how CGM data drive some aspects of insulin delivery.

#### **SECTION 4: ILLNESS, TRAVEL, AND SCHOOL**

Section 4 describes how special circumstances can influence your diabetes care. Although diabetes management can be challenging when you are at home, feeling well, and following your standard routine, special circumstances can make diabetes management more challenging. Situations like illness, traveling (particularly across time zones), or going off to school or college can affect glucose control. Understanding how to adjust your regimen and what to do with your glucose numbers is reviewed in this section. This information will include concepts of advanced pump therapy.

#### **SECTION 5: ADJUSTING TO INSULIN PUMP AND CGM THERAPIES**

Section 5 covers the developmental capabilities of children with regard to managing pumps. Partnering with schools and child care facilities is critical. With cloud-based connectivity, parents are now capable of monitoring their children's glucose levels even when they are not together. You should have realistic expectations of what your child can do with his or her increasing self-management skills. If you don't know what is reasonable, then you might push or hold back your child too much in the quest for independence. Your child's independence is your ultimate goal. When you begin pump and/or CGM therapies, it is like learning about diabetes all over again. You will concern yourself with more insulin dosages and settings, and you will have the ability to continually assess your glucose levels throughout the day and night. When you first start using devices, you may end up thinking about diabetes almost all of the time. This process can cause stress in and of itself. There are critical issues in accepting—and ultimately succeeding with—pump and CGM therapies. These include deciding whom to tell about your pump and CGM, getting used to being attached to one or two devices, and learning how your body image might be affected.

This section concludes by discussing the future and how diabetes technology will continue to advance and will describe the next steps

in the automation of insulin delivery beyond automatic insulin shutoff devices and the hybrid closed-loop systems of today. The next step, a fully closed-loop or “artificial pancreas” system, should result in near-perfect control of glucose levels without much human intervention. The future is bright, and sharing its promise with you will conclude the book.

The goal of this book is to help you understand why you or your child might want to use an insulin pump and a CGM, to give you the skills to use them, and to help you optimize your or your child’s journey with diabetes. Learning to master an insulin pump or CGM may seem overwhelming at the beginning, but these skills can become second nature in no time at all.

