The Impact of Technology on Current Diabetes Management

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KEYWORDS

• Technology • Type 1 diabetes mellitus • Children • Adolescents • Insulin analogues • Insulin pump • Continuous glucose monitoring • Artificial pancreas

KEY POINTS

- Rapid-acting insulin analogues are more convenient to use than regular insulin. Long-acting analogues decrease nocturnal hypoglycemia. Insulin analogues are more expensive than regular and neutral protamine Hagedorn insulin.
- Compared with multiple daily injections, insulin pump therapy is associated with a modest improvement in glycemic control and may be associated with decreased frequency of severe hypoglycemia; available evidence suggests that quality of life is improved and the rate of pump discontinuation is low.
- Continuous glucose monitoring can improve glycemic control in children without increased hypoglycemia. The sensor-augmented insulin pump with low glucose suspension reduces rates of severe hypoglycemia and nocturnal hypoglycemia. Although technological innovations can improve diabetes outcomes and quality of life, maintenance of optimal glycemic control continues to be largely dependent on patient and family motivation, competence, and adherence to daily diabetes care requirements.
- The effective translation of technological advances into clinical practice is costly and requires a substantial investment in education of both practitioners and patients/families.
- Closed-loop "artificial pancreas" systems are currently in development and show great promise to automate insulin delivery with minimal patient intervention.

INTRODUCTION

In the past 2 decades, technological innovations have revolutionized the treatment of type 1 diabetes (T1D). Most recently, new insulin analogues and continuous glucose

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monitors (CGM) have become available to complement improvements in glucose meters, insulin pumps, and pen delivery systems. In clinical trials, these technological advances have been shown to improve clinical outcomes; however, their effective translation into clinical practice is both costly and requires substantial investment in education of both practitioners and patients/families, and has had only a modest impact on clinical outcomes. For example, only 25% of youth with T1D enrolled in the Type 1 Diabetes Exchange Clinic registry in the United States meet the International Society of Pediatric and Adolescent Diabetes hemoglobin A1c (HbA1c) target of less than 7.5%.[1]

The aphorism "A tool is only as good as the person using it" is true for management of T1D in children and adolescents. Advances in technology offer potential opportunities to improve diabetes outcomes; however, successful intensive diabetes management continues to be driven by the competence of the patient/family and their motivation to devote the considerable time and effort required to maintain blood glucose (BG) levels in the near-normal range. Excellent glycemic control is largely contingent on specific self-management behaviors, including, but not limited to, frequent self-monitoring of BG (SMBG) levels, administering insulin before meals, and not missing insulin boluses.[2]

This article focuses on recent technological innovations; however, it is important to appreciate that technology has the potential to improve diabetes outcomes only when the fundamental requirements of effective self-care are firmly in place. Motivated and empowered patients require extensive diabetes self-management education and support to achieve the glycemic goals of intensive diabetes treatment.

NEW INSULINS

After the introduction of insulin in 1922, management of T1D consisted of injections of regular insulin before main meals and an additional injection in the middle of the night; however, after intermediate-acting and long-acting insulins were developed, most patients were treated with only 1 or 2 injections daily. In 1993, the Diabetes Control and Complications Trial (DCCT) showed that maintenance of near-normal glycemia with intensive diabetes therapy reduces the risk of microvascular complications[3] and was the major impetus to develop better insulins, insulin-delivery systems, and insulin-replacement strategies that enable patients to more closely mimic physiologic insulin secretion.

Basal-bolus regimens with multiple daily insulin injections (MDI) or continuous subcutaneous (SC) insulin infusion (CSII, insulin pump), referred to as intensive insulin therapy, aim to mimic normal insulin production, which has 2 principal components: (1) basal insulin secretion suppresses lipolysis and balances hepatic glucose production with glucose utilization, and (2) prandial insulin secretion inhibits hepatic glucose production and stimulates glucose disposal after eating. The ability to simulate endogenous insulin production via SC insulin administration is limited by 2 factors: (1) inability to precisely reproduce the 2 distinct phases of prandial insulin release (a rapid first-phase followed by a more prolonged second-phase), and (2) insulin delivery into the systemic and not into the portal circulation.[4]

In the 1980s, human regular (soluble) insulin produced by recombinant DNA technology was introduced into clinical practice and rapidly replaced animal source insulins. Regular insulin is a short-acting prandial insulin, but its rate of entry into the circulation is too slow to match the absorption of glucose, and it remains in the circulation between meals, imparting a substantial basal component (**Table 1**). This mismatch leads to postprandial hyperglycemia unless injected at least 30 to