



A Pharmacist's Guide to Insulin Pump Technology

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Insulin pump therapy, also known as continuous subcutaneous insulin infusion (CSII), has been in use for nearly half a century and has continued to evolve and grow in popularity.¹ More recent advances in the technology, such as the integration of continuous glucose monitor (CGM) data on the insulin pump screen and the development of pumps that adjust basal insulin rates or suspend insulin infusions when needed, are revolutionizing the management of type 1 diabetes (T1D).² Understanding these advances, as well as the advantages and limitations of available technologies, is key to answering patient questions and providing accurate information to individuals with T1D. This publication reviews the challenges and limitations of traditional insulin delivery systems, explores the benefits and practical considerations of available insulin pump options, and discusses the integration of insulin pumps and CGMs to optimize glycemic control.

LIMITATIONS OF TRADITIONAL INSULIN DELIVERY SYSTEMS

Patients with T1D—and many patients with type 2 diabetes—require insulin to meet individualized glycemic goals.³ Despite its central role in diabetes management, insulin can be a challenging therapy to use for many reasons. These include³⁻⁵:

- The risk of hypoglycemia
- Complex dosing and timing of prescribed regimens
- The challenge of calculating dosing adjustments based on diet and physical activity
- Potential dosing errors and lack of dosing precision with vial and syringe delivery systems
- Injection-site pain/lipodystrophy
- Logistical issues related to insulin storage and administration
- Social issues related to the stigma of self-injecting in public or professional settings

In addition to these challenges, traditional multiple daily injection (MDI) therapy does not mimic endogenous insulin secretion from pancreatic beta cells, potentially leading to large swings in glycemic levels.⁵ Given these factors, the idea of an alternative method for delivering insulin that is minimally invasive and that more closely resembles physiologic insulin secretion is understandably appealing.⁵

INSULIN PUMPS

Insulin pumps offer a solution for many of these issues.⁵ They deliver insulin from a reservoir to provide precise dosing. The insulin is delivered to a subcutaneous catheter either through flexible tubing or through a patch pump, which is attached directly to the infusion site.⁴ Compared with MDI, insulin pump use has been associated with significant improvements in hemoglobin A1c (HbA1c) and a reduced number of severe hypoglycemic events in those with T1D.⁶ Additionally, insulin pumps offer stable delivery and timing, a reduction in the overall injection burden, and insulin delivery that more closely resembles physiologic insulin secretion.⁵

Although insulin pumps offer many potential benefits, they are not appropriate for all patients.⁶ Table 1 outlines select patient-related factors that suggest an individual is a good candidate for insulin pump use.^{1,6}

TABLE 1. Select Clinical, Lifestyle, and Other Characteristics of Good Insulin Pump Candidates

Conditions

- Inadequate glycemic control with MDI
- Erratic and widely variable glycemic levels, including recurrent diabetic ketoacidosis
- Recurrent, severe, nocturnal, or unpredictable hypoglycemia, or hypoglycemia unawareness
- “Dawn phenomenon,” extreme insulin sensitivity
- Special populations (eg, preconception planning, pregnancy, children/adolescents, renal transplant recipients, early neuropathy or nephropathy)

Lifestyle Factors

- Variable/erratic work shifts and schedule
- Frequent need for travel
- Desire for greater flexibility with injection therapy

It is equally important to understand factors that might suggest that an individual is NOT the best candidate for insulin pump use. These may include^{1,6}:

- An inability or unwillingness to continue with glucose monitoring, supplementing with MDI insulin delivery (if needed), and counting carbohydrates
- Poor motivation to achieve greater glycemic control or a history of nonadherence to therapy
- Certain psychologic or psychiatric conditions (eg, psychosis, severe anxiety, severe depression)
- Significant reservations about interference with hobbies and lifestyle
- Unrealistic expectations or beliefs (eg, that pump therapy will eliminate the need for self-management)

TYPES OF INSULIN PUMPS

Several pump systems are currently available.⁷ Pharmacists should be familiar with these and be prepared to answer some common questions about them (Table 2). Although not included in the table below, the V-Go wearable insulin delivery patch (www.go-vgo.com/) is also approved for use in adults requiring insulin, with each patch being worn for 24 hours.⁸

SAFE PRACTICES WITH INSULIN PUMPS

Adverse events related to insulin pumps are most frequently associated with user error, rather than pump malfunction.¹ Pharmacists can support patients using pump technology with specific strategies, including¹:

- **Glucose monitoring.** Patients should be encouraged to monitor glucose using SMBG and/or a CGM to promptly detect hypo- or hyperglycemia. Glucose monitoring may be needed more frequently when starting pump therapy, during illness, or after infusion site changes.
- **Infusion site selection and maintenance.** Patients should change infusion sites at a frequency recommended by the manufacturer (generally every 2-3 days) and monitor for signs of inflammation, infection, lipodystrophy, or insulin leakage.
- **Identifying issues and troubleshooting.** Hypo- and hyperglycemia can be caused by several issues, including:
 - Catheter blockage or dislodgement
 - Battery failure
 - Missed doses
 - Hyperglycemia overcorrection
 - Incorrect pump programming of infusion or bolus rates
 - Incorrect settings for date and time
- **Addressing alarms and alerts.** Patients should review the benefits and limitations of alarms and alerts. Alarms can indicate catheter blockage, low reservoir volume, low battery, and other mechanical issues but may not provide enough warning to prevent hypo- or hyperglycemia. Alerts can offer reminders for SMBG, battery charging, and infusion site changes. However, patients can experience alarm fatigue and may begin to ignore alerts over time.
- **Teaching ongoing glycemic management.** In addition to the usual supply of glucose testing supplies and ketone test strips, patients using insulin pumps will need backup supplies of insulin vials/syringes and/or insulin pens for alternative insulin delivery in the event of a pump failure.

TABLE 1. (continued)

Other Factors

- Highly motivated to succeed, as pump therapy requires significant time and skills training
- Realistic expectations of pump therapy, such as understanding that using a pump does not eliminate the need for self management
- Ongoing willingness and ability to practice self-care behaviors related to management of hypo-/hyperglycemia, stress, diet, exercise, etc.
- Willingness to develop the skills and knowledge needed to self-manage insulin pump therapy independently, including adequate glucose monitoring, carbohydrate counting, insulin dosing and administration, and other factors related to care
- Ability to troubleshoot potential challenges with pump therapy, including engaging in communication with healthcare professionals and using backup insulin delivery approaches when needed

Adapted with permission from American Association of Diabetes Educators. Continuous Subcutaneous Insulin Infusion (CSII) Without and With Sensor Integration. <https://diabetesed.net/wp-content/uploads/2018/03/continuous-subcutaneous-insulin-infusion-2018.pdf>. Accessed May 21, 2020; supplemented by data from Grunberger G, Abelseh J, Bailey T, et al. Consensus statement by the American Association of Clinical Endocrinologists/American College of Endocrinology Insulin Pump Management Task Force. *Endocrine Practice*. 2014;20(5):463-489.

TABLE 2. Available Insulin Pumps

Product	Does it need tubing to administer insulin?	Does it connect to a meter?	Does it integrate with a sensor? ^a	Can I customize the insulin bolus increment if needed?	Is it water resistant?
Omnipod UST400	No	Yes, through wireless technology (within 5 feet)	No, but may be used in combination with any CGM sensor	Yes, from 0.05 to 30 units (increments of 0.05, 0.1, 0.5, and 1 unit)	Yes, up to 25 feet for 60 minutes
Omnipod Dash	No	Yes, through wireless technology	No, but may be used in combination with any CGM sensor	Yes, from 0.05 to 30 units (increments of 0.05, 0.1, 0.5, and 1 unit)	Yes, up to 25 feet for 60 minutes
MiniMed 630G System	Yes, tubing connects the pump to the body	Yes, through wireless technology	Yes, through wireless technology	Yes, from 0.025 to 25 units (increments of 0.025 unit)	Yes, up to 12 feet for up to 24 hours
MiniMed 670G System	Yes, tubing connects the pump to the body	Yes, through wireless technology	Yes, through wireless technology	Yes, from 0.025 to 25 units (increments of 0.025, 0.05, and 0.1 unit)	Yes, up to 12 feet for up to 24 hours
Dana Diabecare IIS	Yes, tubing connects the pump to the body	No	No, but may be used in combination with any CGM sensor	Yes, from 0.05 to 80 units (increments of 0.05, 0.1, 0.5, and 1 unit)	Yes, up to 3.3 feet for 1 hour
t:slim X2	Yes, tubing connects the pump to the body	No	Yes, wirelessly from the Dexcom G6 sensor	Yes, from 0.05 to 25 units (increments of 0.01 unit)	Yes, up to 3 feet for 30 minutes

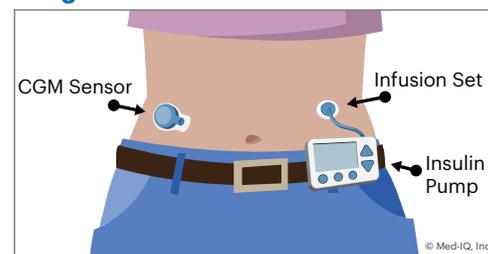
^aIntegration with a sensor implies that the insulin pump directly communicates with and utilizes information from a CGM to adjust insulin delivery.

PAIRING INSULIN PUMPS AND CGMs—AUTOMATED INSULIN DELIVERY SYSTEMS

Given the challenges of both hypo- and hyperglycemia in patients with T1D, devices designed to better mimic endogenous insulin release have long been needed.^{5,9} Automated insulin delivery systems, also known as “artificial pancreas” systems or closed-loop insulin delivery systems, have been in development since the 1970s, with the first system approved by the United States Food and Drug Administration (US FDA) in 2013.^{9,10} The basic components of these systems are a CGM, an insulin pump, and a computer-controlled algorithm that adjusts basal insulin delivery throughout the day based on glucose trends (Figure 1).^{11,12}

Automated insulin delivery systems can offer several advantages to the patient. The MiniMed 670G system, for example, includes an “Auto Mode” setting that automatically adjusts basal insulin delivery based on CGM data in an attempt to maintain glucose levels within a specified target range.¹³ An additional function suspends insulin delivery in anticipation of a predicted hypoglycemic event with programmable threshold alarm features available to warn patients.¹³ Automated insulin delivery technology uses specific algorithms that make small adjustments to the insulin delivery, providing microboluses to avoid hyperglycemia.⁹

FIGURE 1: CGM and Insulin Pump System Integration for Automated Insulin Delivery



Clinical practice guidelines support CGM and CSII use, including automated insulin delivery systems, in appropriate patients who have not achieved individualized glycemic goals or who continue to experience severe hypoglycemia or high glucose variability.^{14,15}

Despite the benefits that automated insulin delivery systems offer, they still require significant time and effort from both the individual with T1D and their healthcare team.⁹ Pharmacists should review common myths and challenges associated with the use of automated insulin delivery systems and counsel patients appropriately. Such challenges may include^{1,9,14}:

- **Requirement for ongoing diabetes self-management.** Despite automated features, some systems still require SMBG calibration with regular, daily fingerstick measurements.
- **Need for carbohydrate counting and manual bolus insulin delivery to cover meals and snacks.** These systems do not work well to correct severe post-prandial hyperglycemia. Patients should also avoid entering “ghost” or “phantom” carbohydrates as an artificial way to deliver more bolus insulin, as this can lead to hypoglycemia.
- **Awareness of default manual mode and alarm fatigue.** Patients should note that insulin pumps can default to a manual mode that requires self-adjustment of insulin delivery, such as in prolonged hypo- or hyperglycemia, loss of sensor signal, or unusually high or low infusion rates. Exposure to false or unnecessary alarms over time can lead to alarm fatigue with potentially serious consequences.

Two automated insulin delivery systems are available (Table 3).¹⁶ Pharmacists should review these systems and understand their general benefits and limitations. Other do-it-yourself (DIY) systems are available that combine a pump, a real-time CGM, and a third-party algorithm designed to automate insulin delivery.¹⁵ However, these DIY systems are not currently approved by the FDA. With any automatic insulin delivery system, pharmacists should educate patients about safe use and the importance of having a back-up plan in the event of a technology failure.¹⁵

TABLE 3. Types of Automated Insulin Delivery Systems in Commercial Use in the US

Product	Interoperable with existing CGMs?	Approval year	Can it suspend insulin for predicted hypoglycemia?	Does it administer automated meal boluses?
MiniMed 670G	No	2016	Yes	No, “Auto Mode” requires user input for carbohydrates consumed and confirmation of mealtime and correction bolus recommendations
t:slim X2 with Control-IQ	Yes	2019	Yes	Yes, premeal boluses are still required, but when forgotten, the system will automatically deliver a bolus of about 60% of the usual meal bolus dose using a target of 112.5 mg/dL

ADDITIONAL RESOURCES



We hope you found this information to be a helpful summary of how insulin pump technologies are advancing insulin management for individuals with T1D. For additional information on this topic, please access these JDRF resources:

- Accredited Learning for Healthcare Professionals (www.jdrf.org/t1d-resources/hcp/)
- Why Insulin Pump Choice Matters (www.jdrf.org/t1d-resources/daily-management/insulin-pump-choice/)
- Type 1 Diabetes Resources and Support (www.jdrf.org/t1d-resources/)

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