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Insulin pumps: Great devices, but you still have to press the button

IN THIS ISSUE OF THE *Journal*, Millstein et al provide an elegant, practical, and up-to-date review of insulin pump therapy (also known as continuous subcutaneous insulin infusion), emphasizing its benefits and comparing it with multiple daily insulin injections.¹

See related article, page 835

■ NOT FOR EVERYONE

While insulin pumps make the lives of many patients much easier, we should be careful when generalizing their indications. These devices have been with us for 4 decades, during which they have progressively been made more precise and more intelligent—and smaller. The technology may be attractive to some patients but undesirable to others (Table 1).

Many healthcare providers are unfamiliar with pump technology, and some are intimidated by it because it involves a dynamic device-user interface that is more complex than that of other concealed programmed devices such as pacemakers. Inadequate glycemic management is complex and may result from factors such as fear of hypoglycemia, difficulty with insulin dose adjustment, and poor math skills.²

Unfortunately, some patients are given a pump without proper screening and education, and they tend to call the pump manufacturer's help line or their provider often for help with technical problems. Selecting the right patient for this technology is more important than the converse.

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TABLE 1

**Advantages and disadvantages
of both types of insulin therapy**

Advantages of multiple daily insulin injections

- No tubing attached
- No risk of skin infection
- No risk of insulin delivery interruption
- More available skin areas for injections

Disadvantages of multiple daily insulin injections

- Need for multiple daily injections with potential for lipohypertrophy
- Need to carry vials, syringes, or a pen
- Need to dispose of more sharps and plastic waste
- Difficulty if the patient has decreased manual dexterity or strength

Advantages of continuous subcutaneous insulin infusion

- Less frequent need to handle needles
- Ability to modify basal rates depending on activity or health status
- Ability to suspend insulin delivery in case of hypoglycemia
- Ability to give a bolus of a fraction of insulin unit in patients with extreme insulin sensitivity

Disadvantages of continuous subcutaneous insulin infusion

- Device is visible
- Potential for device failure and clogged tubing
- Tubing may become tangled on objects
- Cannula may become kinked
- Technology is complicated
- High cost of device and supplies
- Device may malfunction in certain circumstances

Indications for an insulin pump vary by country. In some countries, a pump is started as soon as type 1 diabetes is diagnosed. In the United States, the indications are very rigorous and restrictive, especially for patients with type 2 diabetes, in whom a lack of endogenous insulin production must first be proved.

There is no question that a pump should be offered to every patient with type 1 diabetes who demonstrates good motivation to improve his or her glucose control, but only after a rigorous education program. This option is too costly to be tried just to see if the patient likes it.

■ ADVERSE EVENTS WITH INSULIN PUMPS: MORE DATA NEEDED

A worrisome aspect of continuous subcutaneous insulin infusion at a population level is a lack of information on the root causes of adverse events (diabetic ketoacidosis or severe hypoglycemia) in patients who use it. These events may be serious and sometimes even fatal.

Outside of a controlled environment, it is difficult to ascertain whether an adverse event represents device error or user error, since pumps contain different components (electronic, mechanical, and pharmacologic) that interface with the human user.³ How adverse events are tracked or categorized is unclear, and given the risks associated with this technology, better postmarketing evaluation is needed. Furthermore, we do not know if the precision of insulin delivery decreases over the life of a pump.

While most pump manufacturers have good customer service and make every effort to provide the patient with a replacement pump in case of failure, we do not know if anyone maintains a database of such failures or adverse events, and if those failures can be analyzed to improve safety.³

■ INTERFACES ARE NOT STANDARD

When one buys a new car, little time is needed to learn how to operate it because most cars use the same basic features.

The situation is different with insulin pumps. To compete with each other, pump manufacturers create different looks, different

insulin delivery methods, and different ways of administering a bolus. Switching from one pump to another is difficult without detailed education on the “bells and whistles” of the new pump.

Most patients use just a few features of the pump. They look at it as more of a convenience. They sometimes forget they are wearing it, and even forget to take a bolus before a meal.

■ PATIENT SATISFACTION DEPENDS ON THE PATIENT

For years, we thought insulin pumps were better at improving hypoglycemia awareness. But in a prospective study, multiple daily injections with frequent self-monitoring of blood glucose provided identical outcomes without worsening hemoglobin A_{1c} compared with continuous infusion with real-time continuous glucose monitoring, although satisfaction with treatment was better in the latter group.⁴

Patients' satisfaction with continuous subcutaneous insulin infusion depends on their baseline hemoglobin A_{1c} level. Patients with relatively low hemoglobin A_{1c} tend to take an active approach to self-care, describe the pump as a tool for meeting glycemic goals, and say the pump makes them feel more normal. Patients with high hemoglobin A_{1c} tend to have a more passive approach to their self-care and have more negative experiences with the pump. Women are more concerned than men with the effect of the pump on body image and social acceptance.⁵

■ DOLLARS AND CENTS

According to 2012 estimates, 29 million Americans had diabetes mellitus, of whom 1.25 million had type 1. The direct medical costs of diabetes are estimated at \$176 billion, of which 12% covers overall pharmacy costs.⁶ About 31% of adults with diabetes use insulin.⁷

For a device that costs \$6,000, has a life span of only 4 years, and requires supplies that cost \$300 per month, rigorous interpretation of superiority data would be needed to confirm that this technology would have a positive impact on public health if every insulin-using patient with diabetes were to say yes to it. It is

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true that switching from multiple daily injections to a pump leads to a significant reduction in insulin expenditures in patients with type 2 diabetes, according to a retrospective analysis of claims data.⁸

However, not all studies comparing pumps and multiple daily injections in type 2 diabetes have shown an advantage of one over the other in terms of a reduction in fasting glucose, hemoglobin A_{1c}, or incidence of hypoglycemia.⁹ A meta-analysis¹⁰ found that the two therapies had similar effects on glycemic control and hypoglycemia. Continuous infusion had a more favorable effect in adults with type 1 diabetes.¹⁰

Neither continuous infusion nor multiple daily injections can mimic physiologic endogenous insulin secretion. Endogenous insulin is secreted into the portal system, and its main site of action is the liver. As a result, there is

more hepatic glucose uptake and thus a lower peripheral plasma insulin concentration with endogenous secretion than with systemic administration. Endogenous insulin secretion also suppresses hepatic glucose production and reduces the risk of hypoglycemia.¹¹

■ PROGRESS, BUT NOT PERFECTION

Diabetes mellitus constitutes a big burden on patients and on society. The discovery of insulin was a giant leap forward; the insulin pump was another great advance. We are getting closer to an integrated bionic pancreas. We are far from achieving a perfect system, but we are much better off than we were 50 or 80 years ago. And although insulin pump technology is sophisticated and precise, it still interfaces with a human user, and the human user still must press its buttons. ■

■ REFERENCES

1. Millstein R, Mora Becerra N, Shubrook JH. Insulin pumps: beyond basal-bolus. *Cleve Clin J Med* 2015; 82:835–842.
2. Cavan DA, Ziegler R, Cranston I, et al. Automated bolus advisor control and usability study (ABACUS): does use of an insulin bolus advisor improve glycaemic control in patients failing multiple daily insulin injection (MDI) therapy? [NCT01460446]. *BMC Fam Pract* 2012; 13:102.
3. Heinemann L, Fleming GA, Petrie JR, Holl RW, Bergenstal RM, Peters AL. Insulin pump risks and benefits: a clinical appraisal of pump safety standards, adverse event reporting, and research needs: a joint statement of the European Association for the Study of Diabetes and the American Diabetes Association Diabetes Technology Working Group. *Diabetes Care* 2015; 38:716–722.
4. Little SA, Leelarathna L, Walkinshaw E, et al. Recovery of hypoglycemia awareness in long-standing type 1 diabetes: a multicenter 2 × 2 factorial randomized controlled trial comparing insulin pump with multiple daily injections and continuous with conventional glucose self-monitoring (HypoCOMPaSS). *Diabetes Care* 2014; 37:2114–2122.
5. Ritholz MD, Smaldone A, Lee J, Castillo A, Wolpert H, Weinger K. Perceptions of psychosocial factors and the insulin pump. *Diabetes Care* 2007; 30:549–554.
6. American Diabetes Association. Statistics about diabetes. Overall numbers, diabetes and prediabetes. www.diabetes.org/diabetes-basics/statistics/. Accessed November 4, 2015.
7. Centers for Disease Control and Prevention (CDC). Age-adjusted percentage of adults with diabetes using diabetes medication, by type of medication, United States, 1997–2011. www.cdc.gov/diabetes/statistics/meduse/fig2.htm. Accessed November 4, 2015.
8. David G, Gill M, Gunnarsson C, Shafiroff J, Edelman S. Switching from multiple daily injections to CSII pump therapy: insulin expenditures in type 2 diabetes. *Am J Manag Care*; 20:e490–e497.
9. Gao GQ, Heng XY, Wang YL, et al. Comparison of continuous subcutaneous insulin infusion and insulin glargine-based multiple daily insulin aspart injections with preferential adjustment of basal insulin in patients with type 2 diabetes. *Exp Ther Med* 2014; 8:1191–1196.
10. Yeh HC, Brown TT, Maruthur N, et al. Comparative effectiveness and safety of methods of insulin delivery and glucose monitoring for diabetes mellitus: a systematic review and meta-analysis. *Ann Intern Med* 2012; 157:336–347.
11. Logtenberg SJ, van Ballegooie E, Israël-Bultman H, van Linde A, Bilo HJ. Glycaemic control, health status and treatment satisfaction with continuous intraperitoneal insulin infusion. *Neth J Med* 2007; 65:65–70.

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