

ABSTRACT

It has almost been five decades since the first insulin pump was launched in 1960. The first model was so big that it had to be worn on the back. In 2006, Medtronic MiniMed (Northridge, CA), recognized as pioneers in insulin pump therapy, introduced real-time insulin pumps where the glucose sensor and the pump were combined. The introduction of real-time insulin pumps was a major breakthrough toward “closing the loop” of insulin delivery, very near to the dream of inventing fully automatic devices. At present in India variety of insulin pumps are available. Although there are multiple benefits of CSII, its use has been limited in our Indian set up. Education barrier and affordability issues curtail its usage.

INTRODUCTION

Diabetes is fast gaining the status of a potential epidemic in India with more than 62 million diabetic individuals currently diagnosed with the disease.¹ In 2030 estimated number of diabetics would reach upto 79 million if measures are not taken promptly.¹³ Insulin is the mainstay of treatment for patients with T1DM and long-standing T2DM to achieve good glycemic control. Intensive insulin therapy (IIT) (using multiple daily injections [MDI] or continuous subcutaneous insulin infusion [CSII]) has been shown to reduce the long-term micro- and macrovascular complications in patients with T1DM and T2DM.¹⁴ However, IIT increases the risk for severe hypoglycemia by threefold¹⁵. Although insulin pumps have been around for almost three decades but are becoming common usage only recently. The reasons for low usage of insulin pumps has been high cost, lack of knowledge and availability .

ARTIFICIAL PANCREAS

The artificial pancreas (AP), known as closed-loop control of blood glucose in diabetes, is a system combining a glucose sensor, a control algorithm, and an insulin infusion device. Artificial pancreas (AP) systems will automate blood-sugar management, dramatically reducing T1D-related risks and improving lives of people who have the disease. These systems will monitor glucose levels around the clock and automatically provide the right amount of insulin, and potentially other blood-sugar stabilizing hormones, at the right time. The heart of the system—sophisticated computer algorithms that live on a smartphone or similar device—will link to a continuous glucose monitor sensor and insulin pump to determine blood sugar trends and control insulin delivery.⁴

As AP technology advances, these systems will become

better and better at predicting blood-sugar changes and providing tightly controlled insulin dosing that virtually eliminates hyperglycemic and hypoglycemic episodes. AP systems are on the road to becoming the most revolutionary advance in diabetes care since the discovery of insulin.

However, there are some major limitations associated with the closed loop system such as delay and inaccuracy in both glucose sensing and insulin delivery. They are being worked upon. Bionic Pancreas is one such AP project undergoing clinical trials. “Bionic Pancreas” is the name given to the dual chambered device that comprises two separate pumps for delivering both insulin and glucagon, a CGM, and a control algorithm built into a smart phone.

What is an Insulin Pump ?

An insulin pump (also known as continuous subcutaneous insulin infusion therapy; CSII) is a medical device used for the administration of insulin in the treatment of diabetes mellitus.

A traditional pump includes:

- Pump (including controls, processing module, and batteries)
- Disposable reservoir for insulin (inside the pump)
- Disposable infusion set, including a cannula for subcutaneous insertion (under the skin) and a tubing system to interface the insulin reservoir to the cannula.

It is an alternative delivery mechanism for administration of insulin and is found to be superior to ordinary syringes and insulin pens.²

The device delivers insulin in two ways:

1. Basal (sometimes called background) - delivering small amounts of insulin continuously in order to maintain cell function (replacing the need for long acting insulin)
2. Bolus - delivering a dose of insulin on demand to account for the carbohydrates in meals or to correct high BGLs.

An insulin pump is worn 24 hours a day but can be removed for up to two hours when required, e.g. for swimming, contact sport or showering.

The advantages of the insulin pump (consistency of basal delivery, adjustable basal rates, and low insulin depots allowing the reduction of glycemic variability) have



Fig. 1: Insulin Pump

contributed to its reported superiority compared with multiple daily injections (MDI).³ However, insulin pump therapy is now challenged by new MDI regimens based on long-acting insulin analogues that could replace the use of CSII. As a consequence, health professionals now have to determine which patients are likely to benefit the most from CSII.⁵

Since that time randomized and non-randomized studies have shown the efficacy of CSII across all age groups. Continuous glucose sensors are now changing the way that CSII therapy can improve control by decreasing glycemic excursions and manipulate insulin delivery to avoid otherwise asymptomatic hypoglycemia detected by these sensors.⁶

HISTORY

In 1960 Dr. Arnold Kadish designed the first insulin pump to be worn as a backpack. Unfortunately, little attention was given to Kadish's device due to its impracticality for daily use. A more wearable version was later devised by Dean Kamen in 1976.⁷ Keen and Pickup in 1970's from Guy's Hospital, London reported successful and practical use of a portable insulin pump device for CSII in patients with T1DM.⁸ One of the first commercial insulin pumps marketed in 1978 was the Autosyringe, also named 'Big Blue Brick'.⁹

TYPES

There are various companies, which manufacture and market various pumps in India.

The pumps currently available in India are manufactured by Medtronic and the various models are 722, 640G and 754¹⁰ as shown in Figure 1.

Indications

Despite the increasing popularity of insulin pump therapy, there is no official guideline for the initiation of insulin pump use. There is an agreement of the fact that patient selection is the key since the patient needs to have the thorough knowledge about the functioning and insulin requirement.

In 2009 the American Association of Diabetes Educators

(AADE) published their guidelines, which were as follows:¹¹

- Patients whose hemoglobin A1c (HbA1c) level is greater than 7%, accompanied by frequent severe hypoglycemia (< 55 mg/dL)
- Patients who have hypoglycemic events that require third-party assistance or that interfere with work, school, or family obligations
- Patients with frequent and unpredictable fluctuations in blood glucose levels.
- Patients who perceive that diabetes management impedes the pursuit of personal or professional goals

In 2010, the American Association of Clinical Endocrinologists (AAACE) published their findings about the suitable candidates for insulin pump, which are as follows:¹²

Class 1

Patients are classified as class 1 if they have type 1 diabetes mellitus (DM) and do not reach glycemic goals despite adherence to a maximum multiple daily injection (MDI) and are on a non-CSII program (≥4 insulin injections and ≥4 self-monitored blood glucose measurements daily), especially if they have the following:

- Very labile DM (erratic and wide glycemic excursions, including recurrent diabetic ketoacidosis [DKA])
- Frequent severe hypoglycemia and/or hypoglycemia unawareness
- Significant "dawn phenomenon" (increase in blood glucose levels, usually from 2 am to 8 am, resulting from increased secretion of counter-regulatory hormones, particularly growth hormone)
- Extreme insulin sensitivity
- Special circumstance (eg, preconception, pregnancy, children, adolescents with eating problems, competitive athletes)

Class 2

Patients are classified as class 2 if they have type 1 DM and are on a maximized basal-bolus MDI insulin regimen, defined as more than 3 daily injections, regardless of their level of glycemic control and who, after investigation and careful consideration, feel that CSII would be helpful or more suitable for lifestyle reasons.

Class 3

Patients are classified as class 3 if they have insulin-requiring type 2 DM and satisfy any or all of the following:

- Positive C-peptide results but with suboptimal control on a maximal program of basal/bolus injections
- Substantial "dawn phenomenon"
- Erratic lifestyle (eg, frequent long-distance travel,

shift work, unpredictable schedules that disrupt maintaining timing of meals)

- Severe insulin resistance, candidate for U500 insulin via CSII (eg, type A and type B insulin resistance syndrome, congenital and acquired generalized lipodystrophy, hyperandrogenism–insulin resistance–acanthosis-nigricans [HAIR-AN], Rabson-Mendenhall syndrome)
- Selected patients with other DM types (eg, DM due to pancreatectomy)

Contraindications

- Lack of motivation
- Unrealistic expectations
- Lifestyle problems such as contact sports and sexual activity
- Unable or unwilling to perform multiple daily insulin injections (≥ 3 daily), frequent blood glucose monitoring (≥ 4 daily), or carbohydrate counting
- Psychiatric illness
- Blindness
- Lack of time to attend pump training sessions
- Affordability
- Unable or unwilling to perform multiple daily insulin injections (≥ 3 daily), frequent blood glucose monitoring (≥ 4 daily), or carbohydrate counting

Current scenario of insulin pumps in India

The proportion of T1DM and T2DM patients who are put on the pump would vary from center to center. T2DM comprises over 95% of all diabetes cases in India. The majority of all pump users are also type 2 DM in India.²

The use of CSII is very limited in India because of the cost and the pumps are not covered in insurance policies in India. Education is also a limiting factor in our country. With the recent advances and growing knowledge amongst the physicians, it will lead to proper patient selection and enhanced motivation of the patient. Various companies have also started to market their products in India with wide after sales support for the products to the patients.

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