Overview of Insulin Pump in Management of Diabetes Mellitus

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Abstract

Introduction: Diabetes is a disease in which the body either does not produce or properly use insulin. There are several factors associated with diabetes, from environmental/ genetics to a sedentary lifestyle, obesity, and surgical removal of pancreases. There are many varieties of insulin and many different injection regimens available in the market, which can be used for treatment. However, many find the multiple injection therapy to be cumbersome. In this view, continuous subcutaneous insulin, or the insulin pump, has gained popularity in recent years. It is a physiologic programmable method of insulin delivery that is more convenient, flexible, and lifestyle friendly. The continuous monitoring of glucose sensors provides and predicts the patients’ blood glucose levels. With the advancement of technology, efforts are made to develop a fully automated and independent sensing and delivery system of insulin from sensor-augmented or sensor-driven pumps. Thus, endocrinologists should have sound knowledge on the working of insulin pumps and sensors to ensure a proper dose of insulin, clinical care, and decision making for their patients.

Aim of the Study: Aims of the review are to understand the role of insulin pumps in the management of diabetes mellitus.

Methodology: The review is comprehensive research of PUBMED from 1980 to 2016.

Conclusion: With remarkable advances in replicating pancreases function with devices such as insulin pump has significantly improved the maintenance of blood glucose level, reduction in glycaemic excursions by accurately sensing and precisely delivering the insulin with a check on hypoglycemia by inherent safeguards. And with the emergence of the more advanced and sophisticated system in the future, it will be possible to coordinate the glucose control in the most natural state possible by the use of such precision technology of insulin delivery. Thus a proper education of knowledgeable and motivated patients, along with the support of health professionals, can give the best outcome in reducing the burden of hyperglycemia and hypoglycemia.

Keywords: The Insulin Pump; Diabetes Type-1; Diabetes Type-2; Recent Advancement in Insulin Delivery
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Introduction

Diabetes is a major epidemic in the world. In the human body, the pancreas produces many hormones, including insulin. Based on pancreatic function, diabetes is further divided as type-1 and type-2. Type-1 diabetes develops when the body’s own immune system starts destroying pancreatic beta cells; thus, insulin cannot be produced in the body while in type-2, the body develops insulin resistance and insulin deficiency. Therefore to maintain optimal glucose levels, the diabetic patient requires insulin in the external form [1,2].

Although there are many injection regimens present, the recent advancement in technology leads to the development of insulin delivery with pumps or insulin pumps or otherwise known as continuous subcutaneous insulin infusion (CSII). The insulin pump utilizes short or rapidly acting insulin to avoid and reduce fluctuations in the glucose level. With even more advancement, a newer pump technology has been made to precisely deliver insulin according to the physiological demands of the body. The glucose biosensor provides the data, detection of hypoglycemia, glycemic control, and the programmable insulin is administered [1,2].

Methodology

We did a systematic search for using insulin pump for management of diabetes mellitus using PubMed search engine (http://www.ncbi.nlm.nih.gov/) and Google Scholar search engine (https://scholar.google.com). All relevant studies were retrieved and discussed. We only included full articles.

The terms used in the search were: insulin pump, diabetes type-1, diabetes type-2, recent advancement in insulin delivery.

The working of insulin pumps

The insulin pump work by delivering insulin through a single subcutaneous site chosen for continuous infusion, the site is replaced every 3 days. The insulin used for infusion are rapid-acting and analog insulin and is preferred over regular insulin. The clock is adjusted according to the patients’ glucose profile monitored for 24 hours, and the pump delivers programmable basal insulin accordingly. Insulin requirements and dosage in diabetic patients is affected by several factors such as duration and type of daily activity, exercise, body physiology, illness, and any other medication taken by the patient.

The basal rate varies as single or multiple in 24 hours periods, according to the patient. Most of the insulin pump has the programming of basal rates that can be modified every hour and also shows a temporary basal rate in certain special circumstances. The bolus insulin can also be used for delivering, which takes a few minutes to hours for infusion. The meals are covered by insulin bolus for correction of increased blood glucose levels. The blood glucose level and carbohydrate content of food are two measures that are required to accurately calculate the amount of bolus insulin to be delivered by the pump. Even though it an automated system of insulin delivery, but the patient can suspend the insulin delivery by the pump if necessary [3].

History of insulin pump and the recent advancement

Insulin pumps were first made available for diabetic patients in the year 1970. The earlier insulin pump machines were only used for research and used to be heavy, bulky, and non-handly machines. With these patients manually calculated the amount of bolus insulin required. But with the improvement in technology, the design and functioning of the insulin pump dramatically changed. Due to this reason, insulin pumps gained popularity in recent times. It is estimated in data that over 350000 diabetic population in the US uses an insulin pump, and 30 thousands of those are suffering from type-2 diabetes [4].

The devices at present times use the automatic bolus calculators and deliver the dose of insulin in increments of 0.01 unit/hr. Since the insurance coverage has improved the pump and its suppliers such as cartridges, infusion sets, tubings have become easier to utilize even being expensive. The early day’s devices needed the manual entry of glucose level into the pump, but as the technology advanced, a blood glucose meter is added to device which self-monitor the blood glucose level, transfer the reading and deliver the insulin dose using infrared technology [5].

Some of the insulin pump used are as follow [5]:

- Medtronic Minimed.
- Animas Vibe.
- Tandem Diabetes Care’s t-slim insulin pump (this assimilate touch screen technology which makes it user-friendly).
- OmniPod insulin pump (this comes with tubless and disposable pumps).

**Figure 1:** A. Medtronic Minimed insulin pump with a blood glucose meter. B. T-slim pump with touch screen design. C. Omnipod tubeless insulin pump. D. Medtronic iPro2 continuous glucose monitor [2].

**Figure 2:** Downloaded tracing showing color-coded readings in Medtronic iPro2 continuous glucose monitor [2].
Continuous glucose monitoring

The advent of the continuous glucose monitoring system (CGM) is one of the milestones in diabetes control. The CGM incorporates a subcutaneous sensor that can check glucose reading of interstitial fluid in every 3 to 5 minutes. It gives glucose patterns on an hourly to weekly basis. The information provided on blood glucose is less invasive than the traditional meter used in other insulin pumps [6].

There are two types of continuous monitor available [7-9]:

- The professional CGM - it is used by the physician to check the ambulatory glucose level for 6 days.
- The personal CGM - it is a wireless device used by patients and uses a small sensor implanted subcutaneously, which show glucose value on a receiver device. The other personal CGM are as follow:
  - Enlite Medtronic continuous delivery integrated with Medtronic 530G (Receiving device is eliminated).
  - Dexcom G4 CGM (Animas Vibe insulin pump).
  - FreeStyle Libre flash CGM (Uses 0.5 cm glucose sensor under the skin and require no fingerstick calibrations).

Figure 3: A. Enlite Medtronic CGM integrated with 530G insulin pump and B. Dexcom G4 CGM with Animas vibe insulin pump [2].

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Ideal candidate for insulin pump

The ideal candidate for the insulin pump is the one who is [10]:

- Motivated enough and desires a better glycemic control.
- Have a fair knowledge of how to use this specialized gadget with advanced technology and all the aspects related to pumps to control blood glucose.
- The patient should have realistic expectation from an insulin pump; it neither work without an input nor is a permanent cure for diabetes.
- Patients should know the efforts required and the benefit of switching to insulin pumps from regular insulin injections/ oral diabetic medication.
- Patients should be familiar with the working of continuous subcutaneous insulin infusion technology and the carbohydrate counting since it constantly requires programming and interaction.
- Patients with suboptimal glycemic control even after a multiple-dose of insulin injections.
- Patients with unpredictable hypoglycemia and hyperglycemia state.
- Patients with persistent early-morning hyperglycemia (Dawn phenomenon).
- Patients with an active and hectic lifestyle, shift work, erratic schedules, and frequent travels.
- The young adults and children who demand lesser restriction with treatment and more flexibility.
- Growth spurt, preconception, and pregnancy, presence of gastroparesis.

Advantages of pump therapy

The following are the possible advantages of insulin pump [11-15]:

- It provides a near physiologic basal-bolus insulin delivery, which is comparable to normal pancreatic functions and performs better than the injection regimens.
- It gives the patient more flexibility; insulin dosages can be programmed and administered accordingly regardless of their travel, work schedule, and mealtimes.
- It provides long-term glycemic control in comparison with multiple-dose insulin injections.
- An insulin pump is known to associate with a decreased risk of severe hyperglycemia and works better in emergency care.
- Improved quality of life and reduction of health care cost as compared to insulin injections.
- It uses short or rapid-acting insulin, which minimizes peak absorption-related variables.

Implantable pumps and fully automated insulin delivery

Efforts are made to develop an even better insulin delivery by implanting devices in the intra-peritoneal cavity. This implantable device will come with a sensor, digital handheld control device for reading glucose value, and manipulation of the insulin delivery system of more acceptability with the patient. For refilling concentrated insulin, a subcutaneous side-port can be used. However, there are certain drawbacks present with this, such as frequent infection and malfunction, which would require explanting and re-planting. But it is almost equivalent to pancreas replacement technology in the future [16,17].

The bionic pancreas was studied in type-1 diabetes control. A bihormonal bionic pancreas was tested in both children and adults using a removable sensor inserted under the skin with a thin needle that automatically monitored the real-time glucose values in the tissue fluid. This technology provided both insulin and the hormone glucagon by two automatic pumps through wireless monitored carried by patients. The bionic system reduced the blood glucose level and caused a 37% decreased in hypoglycemia. Although it still requires more testing and sophisticated handling for a certain period [18].

Conclusion

People suffering from diabetes find it very difficult to maintain an optimum blood glucose level and maintaining it to a safe range is extremely important to avoid complications. A well-maintained blood glucose level not only helps in short duration but also avoid the long-term complication of diabetes such as blindness, heart disease, kidney failure, neuropathy, diabetic ulcer, coma, etc. Multiple-dose injections are not very flexible in a current hectic schedule and active lifestyle of people; thus, the emergence of an insulin pump has proven to be beneficial. However, the success of the insulin pump largely depends on the adherence to self-monitor blood glucose and regularly communicating with the professional pump team, the endocrinologist.

Bibliography


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