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ADVANTAGES OF INSULIN PUMP OVER OTHER INSULIN INJECTION

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia and altered metabolism of carbohydrates, lipids and proteins. Insulin is a protein that comes from an organ called the beta cells of islets of langerhans, which is located in the pancreas (mid-abdomen). The main roll of insulin is to control the blood glucose levels. Insulin is normally secreted depends upon intake of food. The people with diabetes having no enough insulin secretion from the pancreas, and in fact, in people with Type-1diabetes have no insulin secretion in beta cells, so the insulin has to be provided by an injection and from 1920s onward insulin shots are the only way to provide insulin**.** If you have good diabetes control with multiple daily injections, but which is launched recently the most obvious reason is that a pump allows you to more precisely dose insulin. We propose a closed loop glucose sensing and insulin delivery system which needs minimal user interference, causes minimal pain, delivers insulin in a controlled amount and does not bruise the body. We propose to call this device "Glucoband", a band which can be worn on the shoulder. It will aim to counter the growing diabetic situation in the country and worldwide. The device will have the following features: The pump itself (including controls, processing module, and batteries); A 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.

Keywords: Diabetes, Micro needle, Cannula, Glucose Sensor, Micro pump, Insulin delivery.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia and altered metabolism of carbohydrates, lipids and proteins. Type 1 diabetes (formerly called insulin-dependent diabetes or juvenile diabetes) results when the pancreas loses its ability to make the hormone insulin. In type 1 diabetes, the person's own immune system attacks and destroys the beta cells in the pancreas that produce insulin. Once those cells are destroyed, they won't ever make insulin again. Type 2 diabetes is a lifelong (chronic) disease in which there are high levels of sugar (glucose) in the blood. Type 2 diabetes is the most common form of diabetes.

Insulin

Insulin is a hormone and like many hormones, insulin is a protein**.** It is secreted by groups of cells within the pancreas called islet cells it is then secreted by the

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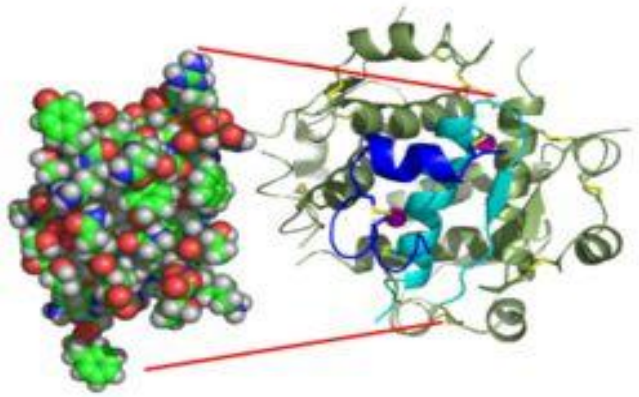
pancreas in response to this detected increase in blood sugar. Most cells of the body have insulin receptors which bind the insulin which is in the circulation. When a cell has insulin attached to its surface, the cell activates other receptors designed to absorb glucose (sugar) from the bloodstream into the inside of the cell without insulin, you can eat lots of food and actually be in a state of starvation since many of our cells cannot access the calories contained in the glucose very well without the action of insulin.

This is why people with type 1 diabetes who do not make insulin can become very ill without insulin shots. Insulin is a necessary hormone. Those who develop a deficiency of insulin must have it replaced via shots or pumps (type 1 diabetes) [1].

Fig 1. Molecular structure of insulin



1. Chemistry

Insulin is a polypeptide with 51 amino acids and a molecular weight of more than 5808. It has two amino acid chains called alpha & beta chains which are linked by disulfide bridges. Alpha chain of insulin contains 21 amino acids & beta chain of insulin contains 30 amino acids.

2. Synthesis

Synthesis of insulin occurs in rough endoplasmic reticulum of beta cells in islets of langerhans. It is synthesized as preproinsulin that gives rise to proinsulin. Proinsulin undergoes a series of peptic cleavages leading to the formation mature insulin and C peptide. C peptide is a connecting peptide that connects alpha and beta chains [2].

3. Actions of insulin on metabolism

- **Glucose transporters**
  The glucose is transported into the cells by sodium-glucose symport pump. When insulin-receptor complex is formed in the membrane of such cells, the vesicles containing GLUT-4 are attracted towards the membrane and GLUT-4 is released into the membrane. The advantage of GLUT-4 is that it transports glucose at a faster rate.
- **Peripheral utilization of glucose**

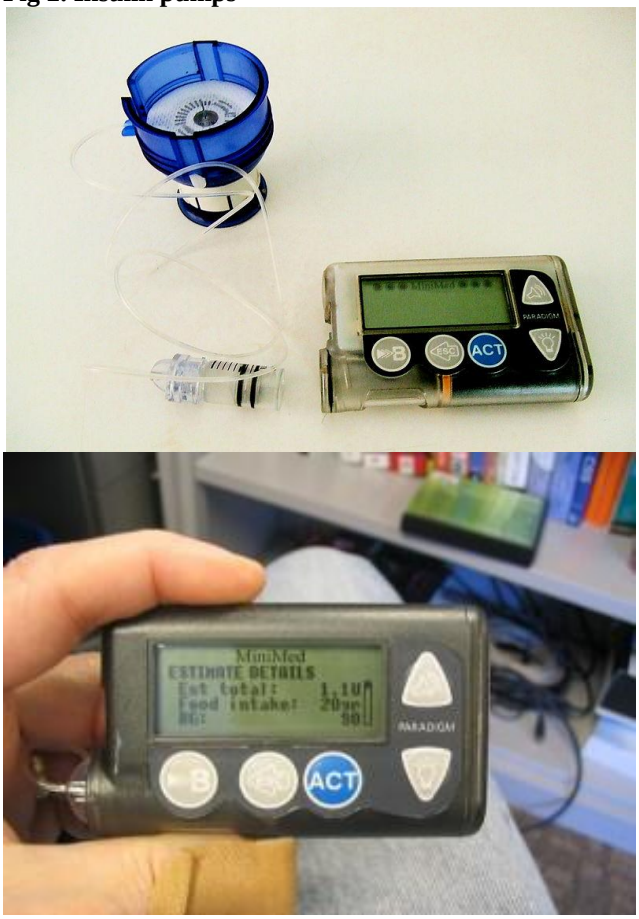
The rate of utilization depends upon intake of glucose. Insulin promotes the rapid conversion of glucose into glycogen, which is stored in muscle and liver. Insulin prevents the breakdown of glycogen into glucose in muscle and liver.

- **Protein metabolism**
  It prevents the catabolism of proteins by decreasing the activity of cellular enzymes, which act on proteins and prevents conversion of proteins into glucose. Thus insulin is responsible for conservation and storage of proteins in the body.
- **Fat metabolism**
  Synthesis of fatty acids and triglycerides, Transport of fatty acids into adipose tissue, Storage of fat [3,4].

4. Insulin pump

An insulin pump is a programmable device that holds an insulin cartridge and delivers a continuous flow (basal rate) of insulin to the body. The pump sends out fast-acting insulin through a short tube with a needle (cannula) at the endpoint that is inserted under the skin, usually in the abdomen. This tubing and cannula are collectively referred to as an infusion set. The cannula and insertion site are changed every two or three days to prevent infection. Newer technology is now available that eliminates the tubing and attaches the pump directly to the skin was shown in following figure 2.

Fig 2. Insulin pumps



Insulin pumps are a reasonable solution for some. Advantages to the patient are better control over background or 'basal' insulin dose, bolus doses calculated to fractions of a unit, and calculators in the pump that help with dosing 'bolus' infusions. As with injections, if too much insulin is delivered or the patient eats less than he or she dosed for, there will be hypoglycemia. On the other hand, if too little insulin is delivered, there will be hyperglycemia. Both can be life-threatening. Insulin pumps require care and effort to use correctly. However, some diabetics are capable to keep their glucose in reasonable control only on a pump.

Insulin pumps are portable and attached to the patient. An insulin pump consists of the main pump unit and holds an insulin reservoir (usually 3ml capacity like the cartridges used in an insulin pen). The reservoir is attached to a long, thin piece of tubing with a needle or cannula at one end. The tubing and the bit at the end are called the infusion set around 1 in 1,000 people with diabetes wears an insulin pump.

5. Functions of the device

1. Detection of glucose levels in the body.
2. Automatic delivery of required quantity of Insulin to the body.
3. Within device storage of a small amount of Insulin for emergency [4].

METHODOLOGY

1. Device design

Components

- **Micro needle:** To extract blood from the blood vessels by injecting the needle into the body in a way to cause minimal amount of pain.
- **Glucose detection system:** Part of the device which will detect the amount of glucose present in the body within 10 minutes.
- **Micro pump:** To pump the blood for it to be detected in the glucose sensing unit and to pump the insulin into the blood.
- **Insulin Delivery System:** This will deliver required amount of insulin through the micro needle and as per the instruction of the control system.

2. Design description

The device consists of a circular disc which holds the microneedles in holes arranged in a circumferential fashion on the disc. The centre of the disc contains the control system which will also contain display. Glucose detection and Insulin delivery units will be on diametrically opposite sides of the disc. There will be plunger mechanism just above the glucose sensing unit which upon pressing will start insertion of the needle and after pressing again will cause the needle to come out of the body. The glucose detection part will be separately held so that the needles on the disc are free to move. Then different needles can come under the plunger and glucose sensing unit in due course of time.

3. Micro pump

Micro pump constitutes one of the most important parts of the whole device as this is responsible for Pumping blood out of the body for analyzing the blood glucose levels. Inject the required amount of insulin depending on the glucose levels in the blood.

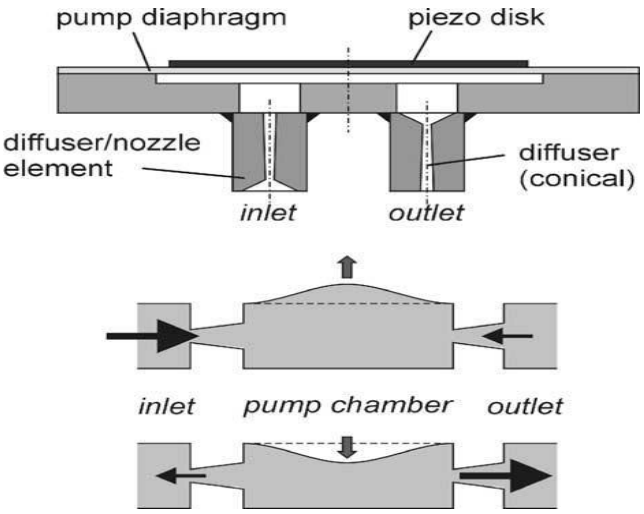
Here in our application we are using a piezoelectric based micro pump which has the capability of driving micro-fluids like blood without inducing any variation in pH value or cell adhesion. Such of these factors is highly important since these problems may result in faulty measurements of blood glucose levels and infections in human body.

4. Piezoelectric Based Micro pump

Principle

We propose to use a micro pump which employs a piezoelectric diaphragm to achieve indirect actuation. Therefore, such kinds of pumps are highly promising for biomedical applications, especially in cases like blood and body fluid transportation.

Fig 3. Piezoelectric Based Micro pump



The pump chamber is closed with a flexible diaphragm on one side. The diaphragm is subjected to oscillations which cause a pressure gradient in the chamber and hence facilitates suction and expulsion of the fluid contained in a container outside. During the “supply phase” the under pressure in the chamber sucks fluid through the inlet and pushes it into the pump chamber during the pump phase overpressure in the pump chamber transfers liquid into the outlet. To be used specifically for our application, the pump should be resistant to blood coagulation and should provide an easy flow of blood through the micro channel.

5. Insulin Delivery

We propose to have rechargeable insulin cartridges as well as reservoirs. We propose to have an alarm system in the device to convey the message to the user to install the new reservoir in place of the finished/almost finished reservoir. Herein, we aim at exploiting the variety in preparations available so as to provide flexibility to the user for using this device. We can easily manufacture insulin reservoirs of different preparations (rapid-acting, short-acting, intermediate-acting, long acting) and the user can choose from different preparations depending on his routine activities.

The application duration of a particular preparation will be broadly fixed though. The preparation/s of the insulin that the clinician recommends based on the severity of the disease and the lifestyle of the patient can be used in the reservoir. Apart from insulin other drugs like in appropriate reservoir patch can also be used. Subcutaneous injection of these drugs will provide faster and better control especially in case of Type 2 diabetes. Insulin formulation can be typically used at room temperature for 7 days, while for long term storage 4° C is preferred [5].

6. Microcontroller

We plan to drive and control our device through a set of microcontroller and other Integrated Circuits optimizing the task in hand. The device will basically work in two modes

1. Glucose Detection
2. Insulin Delivery

The Microcontroller will already be programmed to calculate the optimum amount of insulin to be delivered according to the glucose level just calculated. The microcontroller on having calculated the required amount will order the Insulin Delivery unit through digital message of voltage signals to deliver the exact amount.

Apart from this the microcontroller has to coordinate other units (delivery, micro needle motion, detection etc) and generate signals for the user to maintain and handle the device. An example is that a beep or a blinking LED will be turned on if sufficient amount of blood is not drawn or the device is running out of chemicals and needs refilling.

Use of Insulin Pumps

An insulin pump can help you manage your diabetes. By using an insulin pump, you can match your insulin to your lifestyle, rather than getting an insulin injection and matching your life to how the insulin is working. When you work closely with your diabetes care team, insulin pumps can help you keep your blood glucose levels within your target ranges. People of all ages with type 1 diabetes use insulin pumps and people with type 2 diabetes have started to use them as well. Insulin pumps deliver rapid- or short-acting insulin 24 hours a day through a catheter placed under the skin. Your insulin doses are separated into:

1. Basal rates
2. Bolus doses to cover carbohydrate in meals
3. Correction or supplemental doses

Basal insulin is delivered continuously over 24 hours, and keeps your blood glucose levels in range between meals and overnight. Often, you program different amounts of insulin at different times of the day and night.

When you eat, you use buttons on the insulin pump to give additional insulin called a bolus. You take a bolus to cover the carbohydrate in each meal or snack. If you eat more than you planned, you can simply program a larger bolus of insulin to cover it.

Fig 4. When you eat, you use buttons on the insulin pump to give additional insulin called a bolus

Advantages

Major advances include

1. Development of quick-acting, long acting, and inhaled insulin.
2. Better ways to monitor blood glucose levels and for people to check their own blood glucose levels.
3. Development of external insulin pumps that deliver insulin, replacing daily injections.
4. An insulin pump eliminates the need for insulin injections using a syringe. Instead of multiple injections every day, you only need to reinsert the needle for insulin pump once every two to three days.
5. You may be able to level out many blood glucose swings**.** Because you receive a continuous low dosage of insulin (basal rate) 24 hours a day, you are not prone to the rapid drop in glucose levels that can occur after insulin injections with fast-acting insulin [6].

DISCUSSION AND CONCLUSION

Due to high number of people in India suffering from the diabetes it has become necessary to devise cheap and efficient methods for its cure. At present the focus of clinical studies is mainly on improving the quality of the

medicines for Diabetes Mellitus. In this context it is also necessary to address the root cause of the disease. The proposed research will tend to revolutionize the contemporary viewpoint in as much as it presents a unique and innovative approach to the problem from the national perspective.

At International level, in spite of all the efforts and the research work going into it diabetes was the sixteenth leading cause of global mortality in 1990, accounting for 571,000 deaths. So there is a need to address this issue and come up with a better solution than the already existing ones. Further the present research work done in this area is mainly focused on the specific issues like insulin delivery systems, blood glucose level detection devices etc. We propose the design of an automated device which encompasses both the glucose detection and insulin delivery into a single band.

This pump has great potential in India. It will help the diabetes patients of India in variety of ways. Asian Indians are genetically predisposed to insulin resistance. Because of this, in conjunction with a more sedentary lifestyle improper diet control we are at a high risk of developing type 2 diabetes. India has the highest prevalence of diabetes in the world (32 million expected to increase to 78 million by 2030 according to WHO estimate). Never before this type of initiative has been taken in India to solve the diabetes problem addressing its main reason i.e. insulin. In foreign countries there have been several attempts for insulin pumps but an integrated approach for glucose detection as well as insulin delivery. This device will contribute grossly to such a requirement and will help the patients in maintaining their health on their own.

REFERENCES

1. Sembulingam K, Sembulingam P. Essentials of medical physiology, Fourth edition, 2000.
2. Davis S, Landis B, Adams Z, Allen M, Prausnitz M. Insertion of microneedles into skin: measurement and prediction of insertion force and needle fracture force. *Journal of Biomechanics*, 37, 1997.
3. Sheng-Hung Chiu and Cheng-Hsien Liu. An air-bubble-actuated micro pump for on-chip blood transportation, 2010.
4. Peter Woias. Micro pumps—past, progress and future prospects, Sensors and Actuators, 2009.
5. Al-Tabakha MM, Arida AI. Recent challenges in insulin delivery systems: A review. *Indian Journal of Pharmaceutical Sciences*, 70(3), 2008.
6. Tyagi P. Insulin delivery systems: Present trends and the future direction. *Indian Journal of Pharmacology*, 34(6), 2002.