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Real Time Non-Invasive Glucose Monitoring System

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Abstract

Diabetes is a disease in which the blood glucose level in human body increases from its normal level. The increase in sugar level is either due to insufficient production of insulin in blood cells .When the amount of glucose in blood drops below normal level (i.e. below 70 mg/dL) is called as hypoglycaemia. When blood sugar level is higher than normal level (i.e. 130 mg/dL) is called as hyperglycaemia. Glucose monitoring techniques are categorized as Invasive and Non-Invasive .In invasive monitoring technique, finger pricking is used to determine blood glucose level. In non-invasive technique without taking drop of blood glucose level is monitored .Some invasive techniques are portable glucometer, implantable glucometer while some non-invasive techniques are Tear based gluco sensor, interstitial fluid based, etc. This paper provides all the techniques that are useful for monitoring blood glucose level. The detailed description of each technique is elaborated in this paper. The modern techniques for monitoring blood glucose level which are efficient are also described in this paper

Keywords— Invasive, Non-invasive, Sensor, Glucometer

I. INTRODUCTION

A chronic condition that affects the way the body processes blood sugar is called diabetes. According to the World Health Organization more than 200 million people are suffering by diabetes. As per the recent research held by world health organization (who), in India 69.2 million people are suffering by diabetes [1]. So there is a need for finding the techniques that can monitor the blood glucose level efficiently. The researchers are using various non-invasive optical methods to determine blood sugar level which includes near-infrared, photo acoustic spectroscopy, Raman's spectroscopy, polarization

Technique and light scattering techniques [2]. Diabetes are of two types.Type1 diabetes is known as insulin-dependent diabetes usually developed in children or adults. They need to take insulin daily .Type 2 diabetes is known as non-insulin dependent diabetes .These diabetes people doesn't need to take insulin daily. Currently, diabetic patients are using invasive finger pricking instrument known as glucometer to measure the blood glucose. The continuous glucose monitoring was the first ever growing cheaper, faster and more reliable monitoring method in 1974.

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By pricking the patient's finger using lancet, blood sample is collected to indicate the blood glucose level. Then the drop of blood is placed on the strip and it is inserted into the glucometer. The inner working of the glucometer undergoes number of chemical reactions which produces Potassium Ferro cyanide .This reacts with the metals on electrode layer and causes the electric current to flow through the electrodes. The blood glucose concentration is directly proportional to the Potassium Ferro cyanide production .This leads to greater amount of current to flow through the electrode [3].For having painless measurement process and to diminish the discomfort from repeated finger-stick readings non-invasive techniques are developed.

The purpose of this survey paper is to describe the different types of diabetes and highlight the various methods through which blood glucose can be monitored. The review flows through two main detection techniques: invasive and non-invasive. This paper has attempted to discuss some modern techniques for detecting the blood glucose. The rest of the document is described as follows: section 2 elaborates types of different techniques, section 3 discusses various research papers, and Section 4 concludes the paper.

II. TYPES OF TECHNIQUES

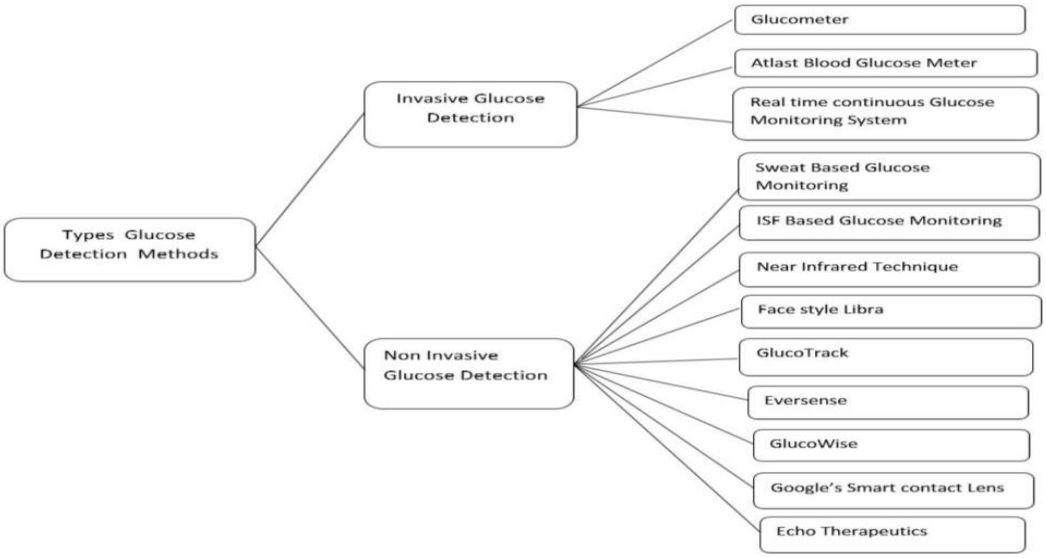

Fig.1 Types of Glucose Detection Methods

As shown in fig.1 the different techniques to detect the blood glucose level. It is mainly categorized into 2 types .Invasive Glucose Monitoring Technique uses the physical contact of finger for pricking and measuring the blood glucose level .Non- Invasive Glucose Monitoring Technique involves other body parts such as skin, eyes, ear, etc. for determining the blood glucose level.

A. Invasive Techniques

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1) Glucometer:

Fig.2 Glucometer

A glucometer is the traditional invasive method used to measure the glucose level in blood using this electronic device. Firstly in this technique blood drop is obtained by pricking the finger. The obtained blood drop is placed on the test strip. This strip is connected to the digital meter which display blood glucose level. A glucometer is a handy small device especially formulated for the diabetics including both high blood sugar and low blood sugar patients. This helps the patients to check and understand their current diabetes or blood sugar level instantly. People can check their blood glucose level at home by themselves using glucometer. By frequent pricking of finger the viscosity of blood increases. The increased viscosity leads to damage capillaries .Further, the finger-pricking glucose meter is not efficient device for continuous monitoring blood glucose level[6].

2) AtLast Blood Glucose Meter:

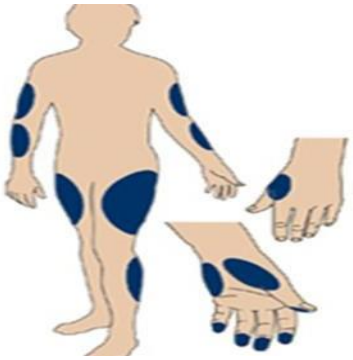

Fig.3 AtLast Blood Glucose Meter

In an AtLast Blood Glucose Meter instead of making use of fingertip it uses thigh, palm as a source of blood glucose detection. The AtLast Glucose Meter works similar to the Glucometer, except blood is drawn in different alternative way. This reduces the pain of pricking fingertips. The obtained blood sample is put onto a strip .The strip is then inserted into AtLast Blood Glucose meter, which displays the result of blood glucose level. AtLast Blood Glucose Meter is less painful than the traditional finger pricking method [10].

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3) Real-Time Continuous Glucose Monitoring (CGM) System:

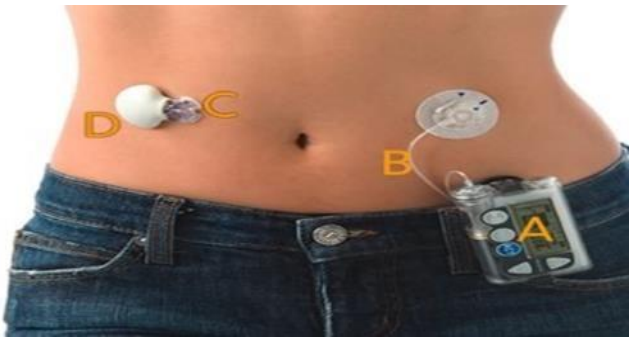

Fig.4 Real-Time Continuous Glucose Monitoring System

In this method MiniMed Paradigm insulin pump is used. MiniMed Paradigm insulin pump is a device that delivers insulin to the body through a small plastic catheter. It is essential to have a sensor to monitor glucose up to 3 days. This sensor is connected to the MiniLink Transmitter. This transmitter sends the data from the sensor to the insulin pump through radio frequency wireless technology. The insulin pump with Real-Time alarms alerts the diabetics when their glucose level is high or low. Thus CGM systems warns diabetics about their glucose level. However this method needs the frequent finger pricking after certain interval of time.

B. Non-Invasive Techniques

1) Sweat Based Glucose Monitoring:

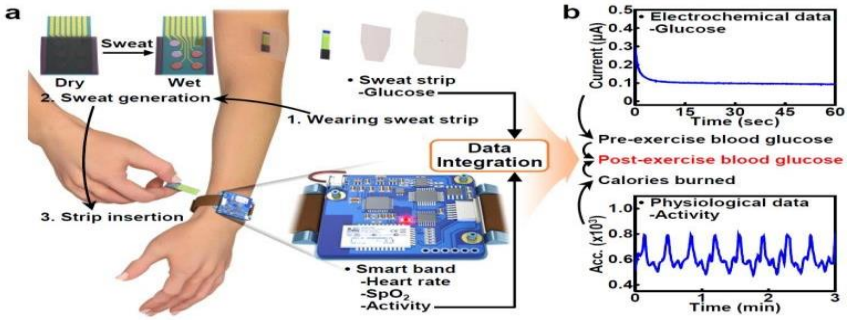

Fig.5 Sweat Based Glucose Monitoring

Sweat Based Glucose Monitoring system consists of a wearable smart band and a disposable sweat-analysis strip for monitoring of blood glucose level in the body. This strip has a multilayered structure which collects, visualize, and analyse the user's sweat. When an adequate amount of sweat is accumulated, the hydro chromic layer of the strip fuses, and then user removes the strip along with its

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protective film and insert it into the smart band. Then the smart band wirelessly transfers the acquired data to the user's mobile device through Bluetooth. As sweat based glucose monitoring is non-invasive technique it does not make use of frequent finger pricking. It is painless and infection-free technique of glucose monitoring. However this technique requires ample of hardware and software interaction [11].

2) Interstitial fluid (ISF) Based Glucose sensor:

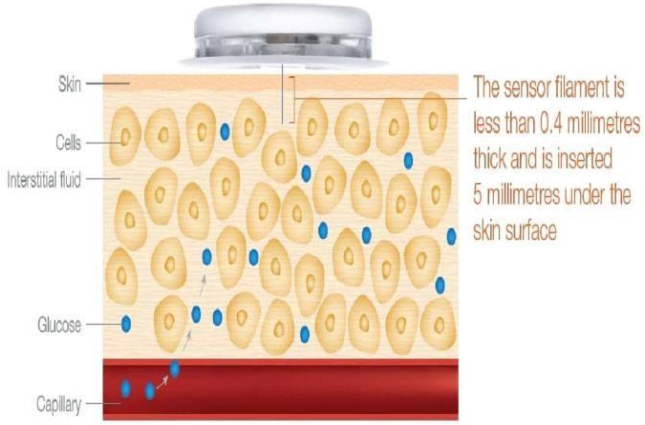

Fig.6 Interstitial fluid (ISF) Based Glucose sensor

As shown in the fig.6 blood glucose in the interstitial fluid is calculated by placing a glucose sensing filament into the subcutaneous tissue. The glucose level in the interstitial fluid nearly follows the blood glucose, with a minor time delay. When a patient's glucose level changes rapidly, the delay is much more noticeable. To overcome this delay, devices which detect glucose in the interstitial fluid makes use of complex algorithms. This results in accurate glucose monitoring for patients. There is a rapid change in both interstitial fluid and capillary blood glucose level, after having meal, giving insulin doses or exercising. Extreme water loss may also cause defective results [4].

3) Free Style Libre:

Fig.7 Free style Libre

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Freestyle Libre contains a smaller sensor strip that is placed on the arm and can be well-worn for up to 14 days. The strip calibrates glucose level in the interstitial fluid under the skin. It is much more affordable CGM option. The blood glucose readings are shown in the form of graph. The sensor is waterproof; hence it can be worn during the bathe. Before use sensor needs to get warm for few hours may be 12 hours. It is not approved as an official reading for blood glucose detection. The Freestyle Libre Sensor lasts for maximum 14 days which results in costly solution.[17]

4) GlucoTrack:

Fig.8 GlucoTrack

Integrity Applications in Israel developed the device called as GlucoTrack. It is battery-operated and has a Main Unit (MU).Main Unit encloses display and control features, as well as transmitter, receiver, processor, and a Personal Ear Clip (PEC).This Ear Clip is clipped to the earlobe. It comprises of sensors and measures the blood glucose levels through a combination of ultrasonic, electromagnetic and thermal waves. The sensor is then linked to a device which displays the blood glucose level [15].GlucoTrack is easy to use. It is pain-free, blood-free, needle free. It provides accurate readings. Unlimited testing is available. It is cost effective. It needs to connect to body part e.g ear. However this technique uses ultrasonic waves to measure the blood glucose level but these waves are transmitted linearly.

5) Eversense:

Fig.9 Eversense

Eversense is developed by Senseonics. Eversense is a subcutaneous embedded that lasts for 3 months. This equipment measures glucose in the interstitial fluid by using a polymer that fluoresces in response to the levels of glucose. The readings are then sent to a transmitter that displays the glucose levels in real time. Life of sensor is 90 days. Eversense produces variety of vibration & audio alerts via phone app

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when placed under the forearm. The transmitter sends alert when there is change in glucose level. It is not affected by acetaminophen use. Transmitter can be removed and replaced without changing the sensor. Sensor insertion (and removal) requires dissection in physician's office. It needs 24 hour warm up period after implantation. It requires assessment twice in a day. Transmitter requires daily charging [8].

6) GlucoWise:

Fig.10 Gluco wise

GlucoWise is a sensor that determines glucose level by just placing it on the earlobe or between the thumb and forefinger. The real-time measurements could then be passed directly to a Smartphone app. It uses radio waves to measure glucose levels .Electromagnetic waves at particular frequencies can be used to monitor blood glucose .However, the skin acts as a natural hurdle and reflects most of these waves. These waves are then manipulated and the readings are obtained on the Smartphone application .Therefore, the challenge with this technique is having sufficient entrance of these waves through the body .Glucowise are portable and easy to use. It reduce long term complications. Its App and Smart Cloud technology convey personalized advice and help to fully manage the condition of glucose level. It can be tested multiple times. The females those are attempting to conceive or the pregnant females cannot use Glucowise. Patients undergoing dialysis treatment can't use this. Patient is not able to read or understand how to use if he /she is illiterate [16].

7) Echo Therapeutics:

Echo Therapeutics is developing its non-invasive, continuous glucose monitoring (CGM) system. In the Echo Therapeutics, to go through the skin before placing the sensor, a special skin preparation device is

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used. By making use of micro-abrasion technology this device abrades the outer layer of skin called stratum corneum for about 0.015mm.This process takes 10 -20 seconds and also measures the physiological properties .This abrasion is done in such a manner that it is shallow and not easily visible. After this abrasion, a biosensor is placed on the permeated skin. These sensors are able to measure the interstial glucose as it flows from the blood surrounding tissues. This serves the patient's glucose level frequently to a remote monitor. The monitor then reflects the rate of glucose level through visual and audible alarms whenever the patient's glucose level varies than the normal level. [3]

III. DISCUSSION

Going through many research papers, various techniques are known for blood glucose monitoring. Continuous glucose monitoring is used to enhance patient treatment and provide an insight into the effect of medications, exercise and diet on the patient.

The first-generation of glucose biosensors was proposed by Clark and Lyons at the Children's Hospital in Cincinnati in 1962. These sensors use the enzyme glucose oxidase (Gox) which is basically an electrochemical approach .The sensor designed provides indirect measurement of glucose concentrations by planting a thin layer of the GOx enzyme on a platinum electrode through a semi permeable dialysis membrane .The third generation of glucose biosensor was developed with the influence of artificial pancreas, which was hypodermically implanted on the patient's body. The interstitial fluid sampling is achieved by invading the skin barrier. This is another method used for monitoring the blood glucose level through the initiation of the skin healing process .GlucoWatch was developed as a wearable device to overcome the process of rupturing the skin to monitor blood glucose level.

IV. CONCLUSION

The Glucose Detection methods are developed remarkably in the last decade. A variety of techniques have emerged, which are impacted by developments in fields such as Sweat Based Glucose Monitoring System, ISF (Interstitial fluid)-Based Glucose sensor, Near Infrared Technique. In this paper, we have discussed Invasive and Non-Invasive Glucose Monitoring Systems. The paper has discussed the characteristic of each technique. The paper provides insight into the concepts involved in detection of glucose concentration, and provokes further advances in the area. The paper has mainly focused on the Non- Invasive Glucose Detection System being need of every diabetic. We have included a list of references that provides a deep understanding of the approaches described.

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