Blood Sugar Measuring Without Sample

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Abstract: Diabetes has evolved as one of the principal health care epidemics of the modern era. At present, the widely used method of self-monitoring of blood glucose (SMBG) involves determination of blood glucose concentration with specific devices using chemical analysis of blood samples taken by puncturing the finger or the forearm. Although SMBG has revolutionized the management of diabetes, discomfort and inconvenience of this invasive technique are frequent barriers for effective compliance and therefore, optimum management. The aim of this paper is to discuss the feasibility study and design issues of noninvasive infrared glucose (NIR) measurement technique using optical method which would be able to overcome the current limitations.

Keywords: Non-invasive Infrared glucose monitoring; optical spectroscopy; electrical spectroscopy.

I. Introduction

Diabetes is the biggest health challenge of the 21st century. It is the major cause of blindness, obesity, ageing population, heart disease, stroke, amputations and renal failure in the world. Diabetes affects the body's ability to produce or utilize insulin, a hormone that is needed to properly process blood glucose. As a result, diabetics must regulate their own blood sugar levels through diet and insulin injections. The key point in the regulation of blood sugar is the accurate measurement of the blood sugar level.

Diabetes and its complications impose significant economic consequences on individuals, families, health systems, and countries. The annual economic cost of diabetes in 2012 in the India was estimated to $174 billion, attributed to both direct and indirect expenditures.

Research has shown conclusively that improved glucose control reduces the long-term complications of diabetes. According to the Indian Diabetes Association, self-monitoring of blood glucose has a positive impact on the outcome of therapy with insulin, oral agents, and medical nutrition. Moreover, SMBG is useful in generating knowledge about individual glucose profiles, as well as knowledge about the effects of one's habits, including exercise and food intake on that profile, thus helping to achieve specific glycemic goals. However, the inconvenience, expense, pain, and complexity involved in SMBG lead to its underutilization, mainly in people with type 2 diabetes. Availability of an accurate, painless, and easy-to-operate device will encourage more frequent testing, leading to tighter glucose control and a delaying/decreasing of long-term complications and their associated health care costs. Noninvasive (NI) methods used for the determination of glucose fall into two categories. The first is based on the measurement of glucose using one or more of its intrinsic molecular properties, such as near-infrared or mid-infrared absorption coefficient, optical rotation, Raman shifts, and photo acoustic absorption, as well as others. These methods assume the ability to detect glucose in tissue or blood independently of other body components or physiological state. The second category measures the effects of glucose on the physical properties of blood and tissue. This category is based on an assumption that glucose is a dominant (highly fluctuating) blood analyze shown in Fig. 1 and, as such, contributes significantly to the change in the A truly noninvasive infrared glucose-sensing device could revolutionize diabetes treatment by leading to improved compliance with recommended glucose levels. Non-invasive monitoring of blood glucose offers many advantages, which avoid pain and discomfort from frequent finger-pricking. This paper deals with the feasibility of the measurement of blood glucose through various non-invasive techniques, which involve light absorption and phase change in the visible and near-infrared wavelengths. Authors have mainly described the method of NI blood glucose determination and the issues regarding components such as incident light wavelength, receiver point, optical model for biological tissue and system design shown in fig.2.

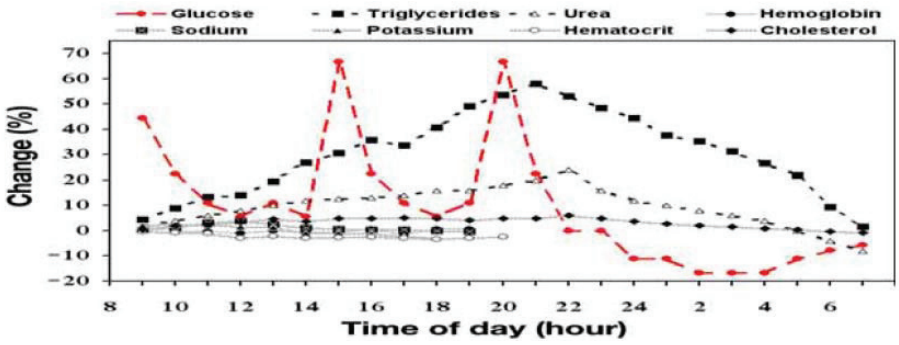

Fig.1: Approximated profile of diurnal variations in serum constituents of healthy individuals expressed as a relative change in percentage from the fasting state. Meals are taken around 8:30, 13:30, and 18:30, denoting breakfast, lunch, and dinner, respectively

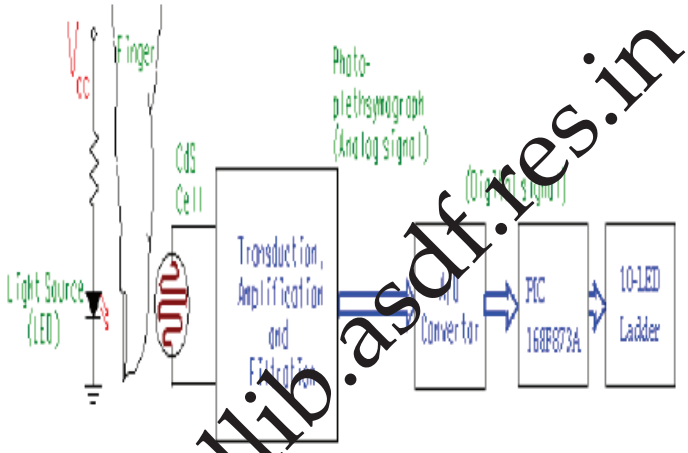

Fig. 2: Non- Invasive Infrared Block Diagram.

II. Background An About Non-Invasive Infrared Methods

Noninvasive techniques include near-infrared and Raman spectroscopy, polarimetry, light scattering, photo-acoustic spectroscopy, polarization technique, mid infrared spectroscopy etc.

In near infrared spectroscopy (NIR) absorption or emission data in the 0.7 to 2.5 μm region of the spectrum are compared to known data for glucose. For Raman spectroscopy, laser light is used to induce emission from transitions near the level excited. Photo acoustic spectroscopy deals with the laser excitation of fluids to generate an acoustic response and a spectrum as the laser is tuned. In scatter technique, the scattering of light can be used to indicate a change in the material being examined. For polarization technique, the presence of glucose in a fluid is known to cause a polarization preference in the light transmitted. Whereas mid infrared spectroscopy deals with absorption or emission data in the 2.5 μm - 25 μm regions to examine and quantities glucose in a fluid.

A. Maintaining the Integrity of the Specifications

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III. Methodology

Detecting the signal induced by glucose is quite difficult because the background signal is dynamic and complex. Absorbance spectra that are measured from skin tissue are influenced not only by water, albumin, globulin, hemoglobin, and triglyceride but also by environmental factors such as temperature and vapor levels. Another major design issue related to NIR blood glucose measurement is calibration due to varying amounts of protein, fats and water in different people. The actual measurement of blood glucose through absorption in the visible to low near infrared region has the problems of interference through protein and fat absorption. Measurement in the near infrared region has the problems with interference from water. Although, satisfactory prediction results have been obtained by most groups in their published papers, problems remain to be unsolved in order to achieve reliable and precise results. There are several critical obstacles preventing from the success of measuring glucose non-invasively. There are many potential sources of interference in the present measurement technique. The stability relies on a constant optical coupling to skin, which is difficult to maintain unless the patient is lying still. Perspiration beneath the probe can also degrade this coupling.

Besides profound methodological problems with the calibration methods necessary for the analysis of absorption measurements, any spectrometric estimation of glucose in skin faces a number of problems mainly significant scattering of light, heterogeneous distribution of light absorbing and light scattering structures which additionally are variable over time (in part due to changes in blood supply and blood oxygenation), unknown path length of light in skin, heterogeneous glucose distribution in skin, presence of many other interfering light absorbers (like water) in much higher concentrations, very similar absorption spectra of water and glucose, temperature dependence of light absorption. The problems listed highlight the design issues relating complexity of noninvasive blood glucose estimations.

Several techniques have been proposed for noninvasive in vivo monitoring of blood and tissue glucose in recent years. NIR spectroscopy for determining the blood glucose concentration non-invasively has been demonstrated by many groups and much progress has been made in the past few years. Optical fibers can be used to measure the NIR spectra of the human forearm.

A NIR spectrometer with a fiber optic accessory can be used for the non invasive measurement of blood glucose. The proposed system has been equipped light source, optical fiber and PIN photodiode. The light returned from the tissue has been received by the fiber optic and collected by the photodiode. Then an ADC is used to convert the analog signal to digital. A microcontroller based circuitry converts the values into corresponding blood glucose value, which is then displayed on LCD shown in fig. 3.

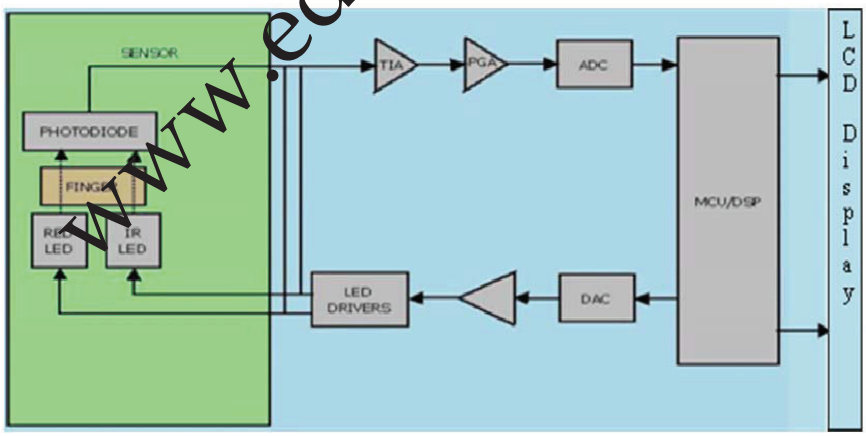

Figure 3: Block diagram of Blood sugar glucose.

The probe contains light sources and detectors operating in the red/near-infrared (RNIR) spectral region and pneumatic cuffs that produce over systolic pressure to occlude blood flow have a special adaptive mechanism for easy positioning and a suitable grip for a wide range of palm sizes, thus assuring user convenience and compliance. The technology is based on the direct effect of glucose on the scattering properties of the organ. Glucose decreases the mismatch in refractive index between scatterers and their surrounding media, leading to a smaller scattering coefficient and, consequently, a shorter optical path. As a result, with the growing concentration of glucose, fewer photons are absorbed and the light intensity increases.

IV. Result Discussion

A total of 135 subjects were tested during both steps of the clinical trial period, producing 793 data pairs. Subjects included 27 type 1 (16 females, 11 males), 98 type 2 (33 females, 65 males), and 10 healthy (7 females, 3 males) subjects, age 55.0 ± 28.8 years, with a body mass index of 28.0 ± 12.3 kg/m2. GlucoTrack readings were compared with invasive finger capillary BG values according to the calibration device: Ascensia Elite in the first stage (83 paired readings) and HemoCue (710 paired readings) in the second stage of the study.

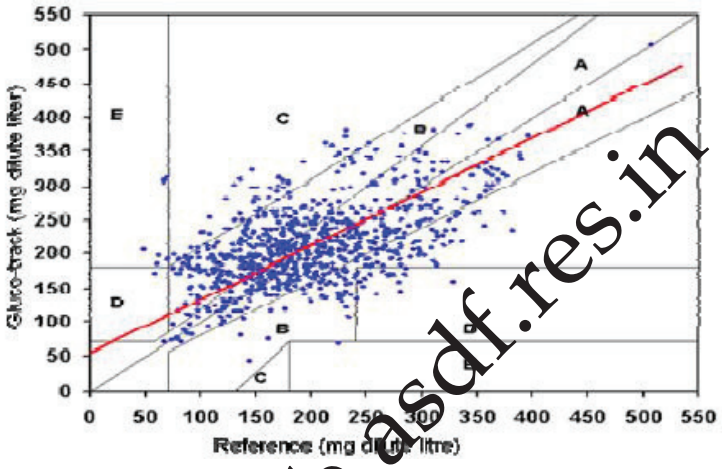

Fig. 4: Pooled Clarke Error Grid analysis for both stages of the clinical trial: A, 50%, and B, 42%.

Our intention is to present data mainly from a clinical perspective (with no statistical implication); hence no assumptions on the distribution of data are necessary. Using Clarke error grid (CEG) analysis, 92% of the readings fell in the clinically acceptable zones A and B shown in fig. 4. The absolute relative difference (ARD) yielded respectively. Evaluation by means of Deming regression fig. 4 with a variance ratio of 0.86 provided an intercept of 53.6 mg/dl and a slope of 0.8 [95% confidence interval for the slope is (0.71 to 0.88)].

VI. Conclusions

Continuous glucose monitoring (CGM) provides additional temporal information, such as trends, magnitude, duration, and frequency of glucose level fluctuations. This information can aid in the identification and prevention of unwanted hypo and hyperglycemic episodes. Furthermore, it can activate alarm signals for extreme glucose levels; decrease the nursing workload in tight glycemic control. CGM can also adjust therapy, quantify the response in diabetic therapy trials, and monitor conditions where tight control without hypoglycemia is sought (Intensive Care Units, gestational diabetes, pediatric diabetes). This study demonstrated the feasibility study and design issues to monitor blood glucose concentration noninvasively in human subjects. The overall investigation into non-invasive measurement techniques for blood glucose indicates that it is a non-trivial problem. Direct absorption measurement is extremely difficult if it is even possible, and the use of interferometric techniques would need to take into account factors such as tissue thickness (i.e. require calibration for an individual). Despite the problems, it is a viable technique for the measurement of glucose concentrations in the blood and requires further investigation.

VII. References

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