Search of the Technological Ways to Improve the Patients with Diabetes Mellitus Quality of Life

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Abstract

This paper considers technical means for the diabetes mellitus optimization, which are directed on: minimization the patient participation in manipulations for disease optimization and its morbidity. Up-to-date methods and devices for glucose level measurement and technical means to help the patients with the analysis and storage of the received data are considered. The developments directed on providing a painless blood sampling and injection of a drug insulin are examined.

Index Terms: Biomedical informatics, Medical information systems, Targeted drug delivery, Medical tests.

I. INTRODUCTION

Today diabetes is an acute medical and social problem that demands radical measures to maintain patients' quality of life. The number of people suffering from this disease all over the world is great, besides an appreciable rate of its gain is observed. In the given paper the analysis of the main trends that provide the search of the ways to improve the patients' quality of life is carried out with the disease basic features taken into account.

II. GENERAL INFORMATION

The diabetes mellitus (DM) is a group of endocrine system diseases that evolve owing to absolute or relative insufficiency of insulin hormone. High content of glucose (sugar) in blood is typical for patients with diabetes. When splitting, glucose gives energy to organism cells and the insulin hormone is necessary for glucose assimilation. The disease is described by a chronic course and disorders of all metabolism aspects.

Approximately 10 % of patients refer to DM of the first type diabetes mellitus, that is described by absolute hormone insulin deficiency (insulin is not produced by an organism) which means insulin injections are necessary a few times during a day. For approximately 90 % of patients DM the second type, non-insulin-dependent DM, is diagnosed. It is characterized by insulin secretion defect and resistance to insulin at oral reception of sugar reducing tablets is indicated [1]. Besides, everyone few years new types and subtypes of diabetes demanding independent consideration and therapy approaches are discovered. So latent autoimmune diabetes among adults (LADA; 1.5 type diabetes») was discovered rather recently. It is a DM, which symptoms and initial course match clinical presentation of the second type DM, but the aetiology is closer to DM the first type.

According to the World Health Organization (WHO), there are approximately 200 million people with diabetes and each year the number of those suffering from the disease

is increased by 4-5% [2]. Millions of people whose living conditions changed by diabetes have to deal with regular events that require self-discipline, self-restraint and patience.

Two components of the patients with DM treatment and life support system are highlighted:

- Glucose level in blood regular monitoring.
- A set of measures that directly depends on the resulting figures.

Reception frequency, quantity and type of drug for all the patients with diabetes mellitus are determined by measuring the level of glucose in blood. As well as that, the glucose level measurement during the day is used for the selection of individual treatment for patients with diabetes. When selection or dosage correction of insulin injections for diabetic patients of the first type the glucose level measurement has to be done several times a day and even at night.

As diabetes is characterized by the violation of all kinds of metabolism: carbohydrate, fat, protein, mineral and water and salt, a set of measures for the maintenance of patients with DM status include diet and exercise control, intake of sugar-reducing agents and/or insulin injections. For example, the physical activity control is very important for patients with diabetes, since intensive physical exercises increase the sensitivity of insulin receptors, which leads to a decrease in glucose level in blood, therefore, in order to avoid hypoglycemia, this reduction is necessary to fixe and adjust the subsequent injection of insulin and/or adjust the next meal.

All aspects of maintaining the patient diabetes closely interact with each other. The most important and decisive factor is the regular measurement of glucose. Since sugar reducing drugs, insulin, diet and exercise are selected individually, then it is necessary to know the body's response to changes in these factors. The body's reaction can show up as an increase (hyperglycemia), normalization (normoglycemia) or decrease (hypoglycemia) blood glucose.

Any action taken without glucose measurement can lead to complications and diabetic coma (sudden hyperglycemia or). Hyperglycemia also eventually leads to the eyes, kidney and nervous system affection. Since hypoglycemia leads to lack of energy, very quickly a risk of brain cells affection arises. So treatment of diabetes is a stable hyperglycemia and hypoglycemia compensation.

Therefore, the first thing in patients with DM treatment and support of life is exactly the systematic monitoring of blood glucose levels. Glucose level control is the most important task for patients with diabetes.

III.   CLASSIFICATION OF GLUCOSE MEASUREMENT METHODS.
ADVANTAGES AND DISADVANTAGES

Let's consider several ways of controlling manipulation, which are divided into two groups:

1) The glucose level detection in urine.

2) The level of sugar in the blood or plasma detection.

The first method uses a test strip to detect the level of glucose in the urine. Its advantages include painless sampling analysis, but the method is not very effective, since the blood glucose levels should be very high for glucose to appear in urine.

In the second control method glucometer devices are used for invasive blood detection sugar level in blood or plasma, when a drop of capillary blood from a finger is applied to

the test strip and placed in the meter. This method is more reliable and accurate, but painful, as patients with diabetes have to repeatedly perform blood sampling. (most accurate and used by the majority of patients the way).

At present noninvasive methods of monitoring are in a stage of working out and give out the big lapse of measurements [3].

Up-to-date glucose meters appearance is an important step in patients with PDM treatment as blood sampling and analysis conducted by a patient with diabetes mellitus independently. Glucometers which effect is based on two technologies of blood glucose measurement: photometry and electrochemistry are available to the modern consumer.

The photometric glucometers principle of operation is based on glucose interaction with a special reagent, applied to the test strip, when there is staining of the test strip in a certain color, the intensity of which corresponds to the concentration of sugar in the blood. Meter's optical system analyzes color changes, on which basis the level of glucose is calculated. This method has some drawbacks: since the optical system is fragile, it requires special care, and the results of measurement have a great error.

The principle of electrochemical glucose meters operation is based on blood glucose interaction with test strips reagent, thus creating weak electrical currents. In this case, the meter records the currents and calculates the concentration of glucose in the blood. Results of electrochemical measurements are more accurate, compared with photometric measurements. The principle of the most modern glucose meters is based on an electrochemical mechanism.

The use of these blood glucose control methods makes it possible to carry out the necessary measurements, but the results also need to be collected and analyzed, trying to identify possible patterns and correlations with certain factors (change in medication or dosage, etc.).

IV.   THE LATEST DEVELOPMENTS AND SOLUTION OF THE PROBLEMS

Glucose level results monitoring is patients' with DM responsibility to a great extent. For stable compensation patients with diabetes are advised to keep a diary. At the daily determination of blood sugar and fixing indicators patterns of oscillation in a few days, weeks, months are identified. You can also identify the pattern of glucose change, depending on a particular type of food, the presence or absence of physical activity, changes in the mode of the day, the workload. Monitoring will coordinate the lives of diabetic patients to optimize the disease.

New programs that perform a task diary for patients with DM can increase the efficiency of observations. Lately applications for mobile phones, smart phones and PCs are actively developed. It allows to add data at convenient time for the patient, store them and adjust the compensation plan for diabetes. They work on the principle of a calculator and their main task is the calculation and prediction: a patient enters information about food consumption, introduces glucose readings obtained by the meter. After the data has been analyzed by the application, the patient receives advice concerning time, concentration and amount of insulin or advice about changing diet.

One of the most popular applications for the Android platform are applications NormaSugar and Diabetesbox. NormaSugar is an insulin dose calculator and online collaboration tool for patients with a doctor. Diabetesbox automatically creates its user a treatment plan at startup - a pattern of actions that a patient with diabetes must make every

day [4]. Of course these applications are very useful, but they require a lot of patient participation. Consequently, the human factor is high and the possibility of errors or inaccuracies is high as well.

In my opinion, when developing ways and mechanisms to decrease discomfort and to increase the quality of patients' with DM life it is necessary to work for the solution of these problems:

I.   decrease in morbidity at:
   A) regular blood samplings,
   B) regular or urgent injections;
II.   Increase of efficiency of patients' with DM condition monitoring and speed of informing taking measures.

The search of the complex solution of the specified problems belongs to the important directions of improvement of patients' with DM life quality.

Nowadays in this direction important scientific and practical steps are observed. I consider it is necessary to mark out the most important of them.

1) In 2011 blood glucometer iBGStar that seamlessly connects to the iPhone and iPod touch was developed by Apple company together with medical company Sanofi [5]. It doesn't differ from electrochemical glucometer by principle of operation, but the result of glucose level measurement automatically remains in the app, the patient doesn't need to enter these values independently.

   Thus, synchronization of the mobile phone and glucometer is provided. The innovation consists in the following – the patient doesn't enter data on glucose level in blood, and this data arrives at once on the mobile phone and is analyzed by the mobile app. By doing this the regularity and objectivity of accumulated information is provided. Nevertheless, iBGStar doesn't relieve patients of a painful blood sampling.

2) In 2010 implanted glucometer that use absolutely new technology of measurement of the glucose level in blood was developed by specialists of University of California in San Diego together with the GlySens company. One of the sensors measures oxygen amount which remained after oxidation of blood glucose with special enzyme (glucose oxidase), and the second - oxygen level in surrounding tissues. The difference in indications of sensors also defines the exact glucose level in blood. The device consists of two sensors, and also the transmitter which sends monitoring data on the external receiver [6].

The specified development of Apple company and University of California in San Diego help to solve the given problems of I.A and II, but don't cover the solution of a problem of I.B.

PDM of the first type inject insulin by using a syringe handle 3-4 times a day. The only modern option for simplification of independent insulin injection for patients with DM of the first type is usage an insulin pump. The Insulin pump consists of the high-precision motor, an electronic part, a display, a tank filled with insulin and a battery. The patient can supervise a dose of insulin injected by means of command keys on the forward panel of a pump. Insulin moves to the patient from the tank hypodermically, more often in a stomach, along a plastic catheter with flexible cannula on its end, entered directly under skin.

Also it is necessary to take into consideration the solution of a task II, as patients with DM of the second type don't depend on daily insulin injections. It happens that they insufficiently responsible when they treat regular measurement of the glucose level in

blood. In case of the neglected control the danger of a diabetic coma occurs and the emergency injection of insulin can be demanded. Also there is an important problem that is an inability of independent drug injection a by the patient in case of sharp glucose level increase.

Since a problem of this research is studying the possibility to relieve patients from daily painful measurement of glucose level in blood and insulin injection, and also to increase an efficiency of a patients' with DM condition monitoring and to minimize the patient participation, it is necessary to consider the problem how to synchronize the mobile phone with implanted glucometer (it is possible with function of emergency insulin injection).

In the solution of this task it can be useful to analyze the development of the electronic implanted chip with the function of injection the teriparatide to patients with osteoporosis. It is conducted by scientists of Massachusetts Institute of Technology (MIT) together with the MicroCHIPS company. This device is implanted into a stomach and contains microtanks with a drug. When the microtanks open the preparation arrives in blood [7].

During further research we consider it to be necessary to carry out the analysis of this possibility and a way of this device adaptation to the insulin for ensuring emergency insulin injection to the second type patients with DM.

V. Conclusions

To sum up, in order to improve patients with DM quality of life, we consider that solution of the following research tasks is important:

- implanted electronic glucometer synchronization with a mobile phone;
- app programming for the Android platform;
- identification of possibility to adapt the electronic chip for the drug teriparatide to the insulin.

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