

ABOUT USING MODERN TECHNOLOGIES AIDED MONITORING OF GLYCEMIC CONTROL IN THE TYPE I DIABETES IN UKRAINE

Abstract

The relevance of investigation due to the constant increase in the number of people suffering from type I diabetes that is diagnosed advantageously amongst the younger population. The article discusses the existing approaches of intensified insulin therapy using individual automatic dispensers for basal-bolus principle. Analysis of the aided monitoring of blood glucose levels has been carried out and a weakness of existing of calculators of boluses has been determined. The operation of such of devices can lead to an inadequate increase of total insulin dose. The solution of this problem is possible when improving existing mathematical models based on base relations, who are used in modern calculators of boluses, and development of intuitive management programs an automated blood glucose control levels. Materials of this article can be used in justify the choice of insulin therapy using insulin's automated doser for patients with type I diabetes.

Keywords

diabetes mellitus, insulin pump, insulin dosing, bolus calculator

AUTHORS

<p>Ivan Smirnov PhD in Medicine, Head of the Department of Endocrinology, PIHC Regional Clinical Hospital - Center of Emergency Medical Care and Disaster Medicine Kharkov, Ukraine <i>diabetes@ukr.net</i></p>	<p>Elena Visotskaya PhD in Engineering, Professor Department of Biomedical Engineering Kharkov National University of Radio Electronics Kharkov, Ukraine <i>evisotska@mail.ru</i></p>
<p>Irina Novikova PhD in Medicine, Head of the Multidisciplinary Clinical Diagnostic Laboratory, PIHC Regional Clinical Hospital - Center of Emergency Medical Care and Disaster Medicine Kharkov, Ukraine <i>mkdl12@ukr.net</i></p>	<p>Andrei Porvan PhD in Engineering, Senior Researcher Department of Biomedical Engineering Kharkov National University of Radio Electronics Kharkov, Ukraine <i>porvan_a_p@mail.ua</i></p>
<p>Yevgeniy Masalitin Student, Faculty of Electronic Engineering Kharkov National University of Radio Electronics Kharkov, Ukraine <i>masalitinj@gmail.com</i></p>	

Diabetes mellitus is a disease that accompanied by metabolic disturbances, persistent hyperglycemia and poses a real threat to health and quality of life. Diabetes mellitus is one of the most common chronic diseases in the World and accompanies humanity in throughout evolutionary history. According to the International Diabetes Federation in 2015, 415 million adults with diabetes mellitus were registered in the world and to 2040 this number could reach 642 million (WHO Media center, 2015). In Europe the

number of people (aged from 20 to 79 years old) suffering from diabetes mellitus is 9,1% and ranges from 6,8 to 13,0% in various countries. In European populations, noted the high prevalence of type 1 diabetes among children is (IDF diabetes atlas, 2015). In turn, according to the Ukrainian Diabetes Federation, in Ukraine life of more than 160 thousand patients depends on the timely and proper insulin delivery.

In the treatment of diabetes mellitus two periods can be clearly identified: before insulin (till 20th century), when the diagnosis "Diabetes Mellitus" almost had no chance to patient survival and "New Age", associated with the discovery of insulin in 1921 which is injected to patients with type I diabetes since 1922. Treatment was successful and then the diabetes mellitus ceased to be a fatal disease (Leutholtz, 2011).

A necessary condition for maintaining the optimum blood glucose concentration is the accurate dosing of insulin per unit of food and correction of glycemia. Automatic system of permanent glucose monitoring and insulin pumps which allow to continuously injecting insulin into the subcutaneous tissues are widely used in the world.

When using insulin pumps it does not form depot of insulin, reduces the risk of hypoglycemia and it is possible to stop the pump and stop insulin delivery. Some of insulin pumps model allow not only injecting insulin, but also monitoring of blood glucose levels in real-time. Insulin pumps can have a built-in program - "bolus calculator" which allows calculating the appropriate dose of insulin. Spend specialty setting of program and its timely correction for accurate calculations in each case. Study of different methods of insulin delivery and estimate of their efficacy and safety will help to develop algorithms for the treatment of patients with type I diabetes, minimizing the risk of acute and chronic complications.

In this article will consider the problem of diabetes mellitus self-management and the existing ways to solve it problem with the help of aided dosers with bolus calculator.

The most effective way to glycemic control in patients with type I diabetes is still intensified insulin therapy at the present time which can be carried out in multiple injections of insulin or by continuous subcutaneous injection insulin by means of individual aided dosers on the basal-bolus principle (Dedov, 2010, Astamirova, 2001, Emelyanov, 2012).

The basic principle of intensified insulin therapy is an independent adaptation of insulin doses to the amount of carbohydrates in food, to indicators of self-control of glycemia, physical activity and other states of human body which creates constant need to carry out of calculations to the patient.

Today there are many bolus calculators can be integrated into various electronic devices with software and actively implemented into different pump action dosers. Nevertheless, modern bolus calculators are not fully self-sufficient tools to improve glycemic control and current methods of assessing the different situations, that can get the patient, has a several disadvantages. At the same time the individuality of each patient with type I diabetes is a major factor for the calculation of dosage errors (Kargina, 2010, Chernetsov, 2010). For example, when entering the same amount of carbohydrate at one meal one patient blood sugar level have been from 7 to 10 mmol / l, and another 15 mmol / l which is due to the influence of a variety of factors (diet, lifestyle, comorbidities, etc.). These factors must be considered when calculating the individual dose. The problem of adequate insulin delivery which is as close to the physiological rhythm of its secretion can be solved using an appropriate mathematical apparatus and information technology.

In-depth analysis of the methods and means of glycemic control in type I diabetes can help to determine the right way of solving the assigned task and identify ways of further research.

Currently, firmware bolus calculators are present and widely used in most insulin pumps including in the world producers of devices such as Medtronic MiniMed (US), Roche (Switzerland), Sooil Dana (South Korea)

According to the data in 2013 on the proportion of the global market for the devices above producers of entire product range is 19%, 13% and 19%, accordingly (Trunova, 2013). The algorithm of the bolus calculator program is similar in all cases. In calculating of doses accounted carbohydrate ratio, insulin sensitivity, target glycemia (at a given time), the current concentration of glucose, as well as the essential elements is the concentration of carbohydrates in food and quantity of active insulin. The units of measurement of carbohydrates, which make the pump, can be grams and bread units.

Calculations of most bolus calculators are based on a common formula for calculating bolus doses:

$$(BU*CR) + (GC - GC_{target}) / ISF - act.ins., \quad (1)$$

where *BU* is a bread unit;
CR is a carbohydrate ratio;
GC is a blood glucose concentration;
GC_{target} is a target blood glucose concentration;
ISF is an insulin sensitivity factor;
act.ins. is a level of active insulin.

As can be seen from the description the first part of the formula is responsible for the calculation of the dose at one meal. This part of the formula operates identically for all insulin pumps. The main differences "calculators" for the second part of the formula needed for calculating dose to the correction of glycemia (Filipov, 2012, Barnard, 2012).

Many pumps issued by built-in bolus calculators are also equipped with a built-in blood glucose meter. It allows evaluating the blood glucose levels in the real-time mode and carrying out calculations in accordance with the dynamics of the blood sugar level changes, which is automatically recorded on the microchip device (Accu-Chek, 2015, Hoogma, 2006).

So, the mathematical relationship based on the amount of active insulin in the blood and correcting insulin dosage according to (1) is a distinguishing feature of the Medtronic Co. insulin pumps. If the active insulin than is needed to correct hyperglycemia, bolus calculator will not offer to inject insulin, irrespective of the glycemic index. Thus, the greater active insulin dose for the moment of calculating, the greater the glycemic index, in which bolus calculator will not calculate a correction dose. If the amount of active insulin is not considered, it could potentially lead to an overestimation of inadequate total dose of insulin. Thus, at a low rates of glycemic bolus calculator will calculate dose, which is introduced, taking into account the lower limits of the target values. But when glycemia level below 3.9 mmol / l, pump Paradigm MMT 712 (Medtronic Co.) does not allow to inject insulin to the patient (Phillip, 2007).

To pump Accu Chek Spirit Combo firm Roche, the formula is slightly different from (1) has been designed. Calculations carried out taking into account the coefficient (*k*), which allows you to increase or decrease the amount of insulin, injected pump, according to state of the user (physical activity, concomitant diseases, etc.):

$$k*[(BU*CR) + (GC - GC_{target}) / ISF - act.ins.]. \quad (1)$$

Value of *GC_{target}* associated with the presence of active insulin and coincides with the mid-range of the target values glycemia as can be seen from the formula (2). In

contrast to other pumps, the dose calculation for correction occurs even in the case where the glycemia included in the target range.

Bolus calculator of pumps AccuChek Spirit Combo calculates correction dose (for all cases of glycemia), regardless of the amount of active insulin. But if the patient has hypoglycaemia, the insulin pump is not injected (Accu-Chek, 2015). At the same time bolus calculator will be calculated value of the amount of carbohydrates needed for the normalization of glycemia. In the case of hyperglycemia Roche Co. pumps will enter deliberately more insulin.

Known OmniPod System (US) offers the possibility of remote control via the pump control panel in which there is a built-in calculator doses using the active insulin devoid of shortcomings AccuChek Spirit pumps series. Aided calculator in this system allows for self-control diary and keeping a core set of products that patient uses (OmniPod System, 2015).

The analogue of OmniPod system is a pump of Solo system (Israel). Bolus calculator built into the system allows calculating the insulin doses according to the level of active insulin and a core set of human consumption products.

The advantages of the system are the low weight (76 grams) and the presence of attachment in the form of a patch that delivers a patient ease of movements (Cukierman-Yaffe, 2011).

However, the disadvantage of the considered systems and calculators is lack of integrating the individual characteristics of the patient, his lifestyle and diet, and existing software solutions are not publicly available, has a complicated programming interface that requires special training.

Thus, the improvement mathematical models, used in bolus calculators with the aim of integrating parameters and factors of glycemic control in type I diabetes, is the actual scientific task.

In turn, using of these models as a mathematical support for aided monitoring systems of glycemic control in the type I diabetes has practical interest.

One of the main factors affecting the success of using of the aided monitoring systems of glycemic control in mobile dosers is the existence of the program to automatically calculate bolus doses. Despite the success of foreign companies modern bolus calculators built in the pump are not completely independent of glycemic control tools. This is due to the lack of a number of factors accounting individualizing the process, so that the patients prefer using the empirical method of selection of the dosage of insulin and meals. Solution to this problem is possible with the improvement of relevant mathematical models based on the basic relations that are used in modern bolus calculators and developing automated control of glycemia system with an intuitive interface.

Materials of this article can be used in justify the choice of insulin therapy using insulin's automated dozer for patients with type I diabetes.

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