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Commodity aspects of insulin pumps use in diabetes mellitus therapy

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ABSTRACT

In the paper the significance of insulin pump in insulin-dependent diabetes mellitus therapy is presented; data have been generalized and contribution percent of every manufacturer-country and manufacturer-company on the insulin pumps world market has been defined, the leader has been found; comparative characteristic of several types of the device by basic parameters has been composed; basic consumer aspects have been characterized; factors to be considered by a consumer choosing the device have been listed; current status of the pumps implementation in therapy of diabetes mellitus has been described and also data given on the use of the pumps in Ukraine; the basic characteristics of the pumps use have been presented and main consumer advantages have been outlined.

Key words: diabetes mellitus, insulin pump, bolus.

INTRODUCTION

World Health Organization reports that now in the world 6% of population suffer from diabetes mellitus (DM) which is approximately 284,7 million people [1,2]. According to experts, the number of patients will continue to grow, and by 2030 they will have 438.4 million. Diabetes today is really a serious medical and social problem [3,4,5,6].

Diabetes mellitus - a group of endocrine diseases, developing as a result of an absolute (type I diabetes - insulin-dependent) or relative (type II diabetes – insulin-non-dependent) deficiency of insulin hormone, resulting in hyperglycemia development - a persistent increase in blood glucose level [7, 8]. The disease is characterized by a chronic course and violation of all kinds of metabolism [9, 10, 11].

Recent studies confirm that people with DM, often have a range of psychological problems and mental disorders. Such violations not only cause suffering, but also affect the treatment and outcome of the very DM [12, 13, 14]. In other words, due to this disease in patients is significantly reduced quality of life. And the task of physicians is to pick for a particular patient the most effective treatment, and today it is also to minimize the inconveniences caused by this disease (need for continuous monitoring of blood glucose, insulin dose calculation, time-based injections, etc.) with regards to type I diabetes, at necessity of replacement therapy [15,16,17]. Such device as insulin pump may be extremely helpful to handle this task [18, 19, 20, 21, 22, 23].

EXPERIMENTAL SECTION

Insulin pump - is an electromechanical device for subcutaneous injection of insulin continuously in accordance with the downloaded instructions [24,25].

The advantages of insulin pump use are:
- achievement of the optimal level of glycated hemoglobin (HbA1c) [26];

- reduced risk of complications (retinopathy, nephropathy, neuropathy) [27];
- achievement of better indices of carbohydrate metabolism [3];
- setting the mode of insulin administration closely to the profile of the physiological secretion [28,29];
- more flexible adjustment of the blood glucose at change in diet, physical activity, etc.[30,31];
- reduced total number of injections because for several days (1-3) insulin is delivered via a catheter, which can be compared with a single injection of insulin;
- reduced peripheral hyperinsulinemia, which avoids the insulin overdose [32];
- a more active lifestyle, which is achieved by varying the flow rate of insulin, improved patient's social adjustment [33,34,35,36,37].

In the Table 1 data of insulin pumps manufacturers on world market are presented.

Table 1 World market of insulin pumps manufacturers

№	Model	Company	Country
1.	H-Tron plus	Disetronic	Switzerland
2.	Accu-Chek D-Tron	Roche	Switzerland
3.	Accu-Chek Spirit	Roche	Switzerland
4.	Accu-Chek Combo	Roche	Switzerland
5.	MiniMed 508	Medtronic	USA
6.	Paradigm 512/712	Medtronic	USA
7.	Paradigm 522/722	Medtronic	USA
8.	Paradigm VeO (554/754)	Medtronic	USA
9.	Dana Diabecare II	Sooil	South Korea
10.	Dana Diabecare IIS	Sooil	South Korea
11.	Dana Diabecare IISG	Sooil	South Korea
12.	Dana Diabecare IIR	Sooil	South Korea
13.	Animas IR-1250	Animas	USA
14.	Animas IR-2020	Animas	USA
15.	OneTouch Ping	Johnson & Johnson	USA
16.	Deltec Cozmo	Smiths Medical	USA
17.	Amigo	Nipro	Japan
18.	BestLife	Diamesco Co., Ltd	South Korea
19.	OmniPod	Insulet	USA
20.	Solo	Medingo	Israel
21.	V-Go	Valeritas	USA

Analizing the structure of insulin pumps manufacturers we can see the share of each manufacturer-country (Fig. 1).

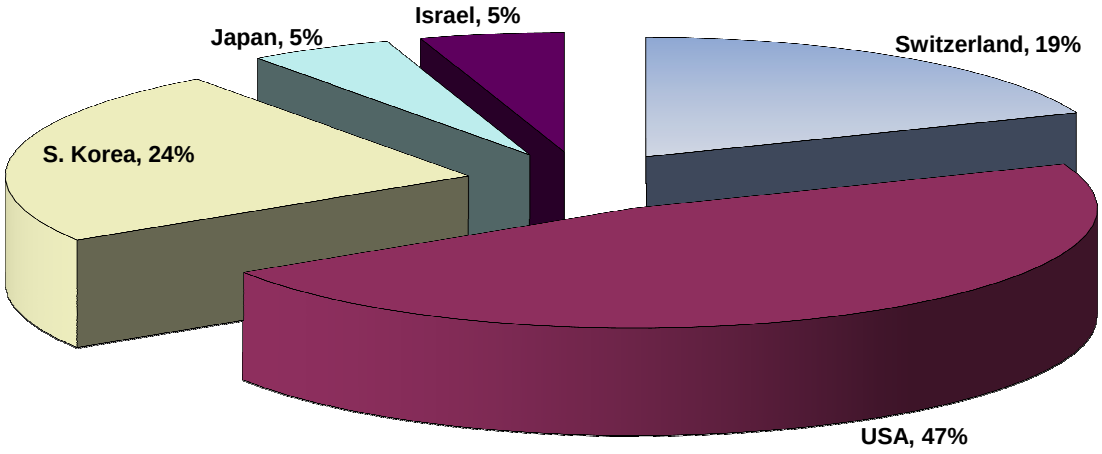

Fig. 1 Range of insulin pumps, depending on the country of manufacture

The percentage of each particular manufacturer in the market - respectively the breadth of products range is shown in Fig. 2.

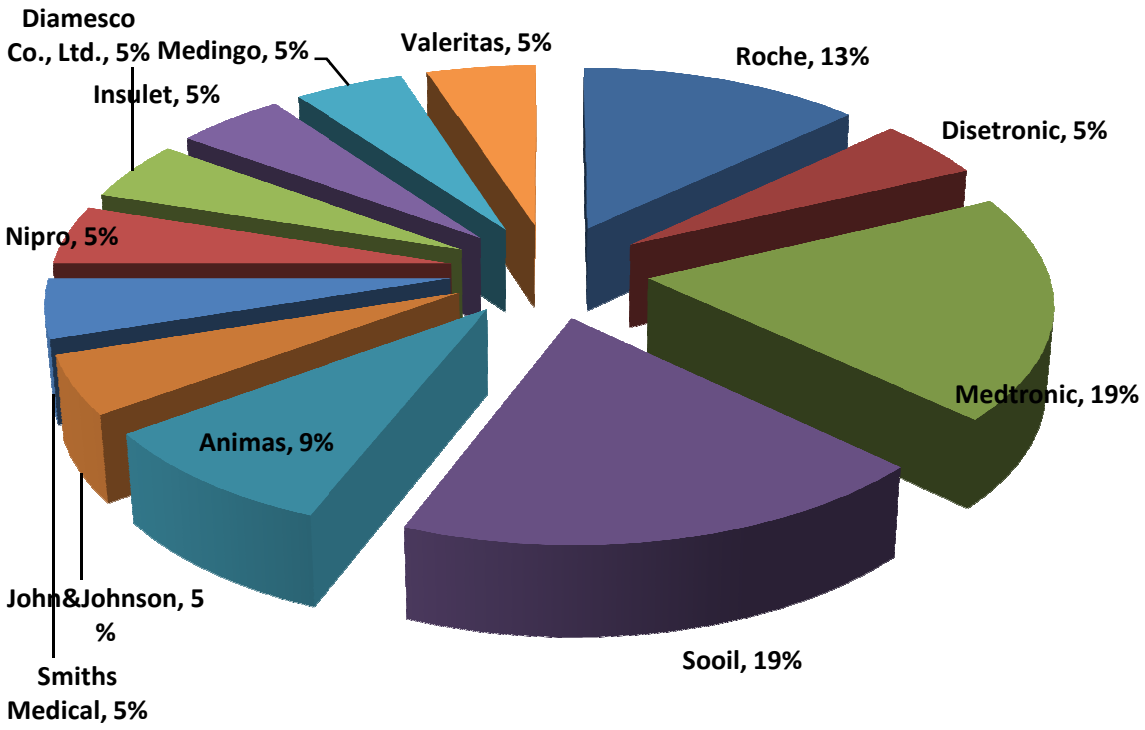

Fig. 2 Market share of insulin pumps of specific manufacturer

Comparative characteristics of insulin pumps from different manufacturers, on the Russian market as a leader of the CIS countries, by the main parameters is given in Table 2.

An insulin pump does not use long-acting insulin. As basal insulin short or ultrashort-acting insulin is used. The insulin pump delivers one type of insulin of short or ultrashort-action in two ways: bolus - the dose delivered to the meal or to correct high blood glucose. Basal dose is supplied continuously with adjustable basal level for insulin requirements between meals and at night. [38,39,40,41].

The indications for the beginning of therapy are:
1. Often heavy hypoglycemia;
2. Significant fluctuations in glucose levels during the day, regardless of the level of glycated hemoglobin;
3. Uncompensated diabetes mellitus (exceeding the target level of HbA1c);
4. The presence of complications;
5. The complexity of self-control in the mode of multiple daily injections.

Other circumstances in which it is desirable to start pump therapy:
1. Small children, especially neonatal children and infants;
2. Adolescents with eating disorders [42, 43];
3. Children and adolescents with severe phenomenon of "morning dawn";
4. Fear of injections;
5. Pregnant or planning a pregnancy women;
6. Children prone to ketoacidosis;
7. Regular exercise [44, 45, 46].

Contraindication to insulin pump therapy is low vision because the user needs to see what's happening on the pump screen or he should have a round the clock assistant who can help him in this. The device is also not applicable at mental diseases [47, 48, 49].

Table 2 Comparative characteristics of insulin pumps by basic parameters

№	Model	Dana Diabecare IIS	Accu-Chek Spirit	Accu-Chek Combo	Paradigm 512/712	Paradigm 522/722	Paradigm VeO (554/754)
1	***Manufacturer***	Sooil	Roche	Roche	Medtronic	Medtronic	Medtronic
2	***Country***	S. Korea	Switzerland	Switzerland	USA	USA	USA
3	***Pump type***	separate	separate	separate	separate	separate	separate
4	***Weight (g)***	60	136	136	512: 99; 712: 108	522: 99; 722: 108	524: 99; 724: 108
5	***Reservoir volume (units)***	300	315	315	512: 176 712: 300	522: 176 722: 300	524: 176 724: 300
6	***Catheter connector***	Proprietary	Luer	Luer	Proprietary / luer	Proprietary / luer	Proprietary / luer
7	***Step of basal insulin (units)***	0,1 or 0,01	0.1	0.01	0.05	0.05	0.025
8	***Basal intervals per day***	24	24	24	48	48	48
9	***Basal profiles***	1	5	5	3	3	3
10	***Basal interval timing (min)***	60	60	60	30	30	30
14	***Basal insulin supply***	Every 4 minutes	1/20 of an hour dose every 3 minutes	1/20 of an hour dose every 3 minutes	0,05 units in equal time intervals (BioSystem)	0,05 units in equal time intervals (BioSystem)	0,025 units in equal time intervals (BioSystem)
15	***Time basal***	Change with a step of 10% from 0% to +200%	Change with a step of 10% from 0% to 200% from 15 minutes to 24 hours	Change with a step of 10% from 0% to 200% from 15 minutes to 24 hours	Change with a step of 0,1 unit, or from -100% to +200%	Change with a step of 0,1 unit, or from -100% to +200%	Change with a step of 0,1 unit, or from -100% to +200%
16	***Minimal step of bolus insulin***	0.1	0.2	0.2	0.1	0.1	0.1
17	***Bolus types***	normal, extended, double	normal, deferred, extended, multiwave	normal, deferred, extended, multiwave	normal, extended, double	normal, extended, double	normal, extended, double
18	***1 bolus unit injection timing (sec.)***	12	5	5	30	30	30
19	***Calculation of doses for meal and for correction***	Yes	No	No	Yes	Yes	Yes
20	***Battery operating time***	8-10 weeks	4 weeks	4 weeks	3 weeks	4 weeks	5 weeks
21	***Memory***	Energy-non-dependant, 100 days	Energy-non-dependant, 90 days (4500 events)	Energy-non-dependant, 90 days (4500 events)	Energy-non-dependant, 25 days	Energy-non-dependant, 25 days	Energy-non-dependant, 25 days
22	***Water resistance***	IPX 8, 60 minutes on the depth 2.5 meters	IPX 8, 60 minutes on the depth 2.5 meters	IPX 8, 60 minutes on the depth 2.5 meters	Splash protection	Splash protection	Splash protection
23	***Warranty***	4 years	4 years	4 years	4 years	4 years	4 years
24	***Certificates***	FDA, CE, RF	FDA, CE, RF	FDA, CE	FDA, CE, RF	FDA, CE, RF	FDA, CE, RF

If we consider an insulin pump from merchandising point of view, the main object of study is consumer aspects. They are such parameters as minimal dose of basal insulin per hour, bolus insulin supply step, automatic doses calculation, types of boluses, number of basal intervals, minimal duration of a basal interval (minutes), number of basal insulin profiles, memory (days), error alert system, low and high sugar level alert system, real time blood sugar measurement, buttons lock, remote control, PC connection, Multilanguage pump menu, guarantee for the device, water resistance, reservoir volume [50,51,52,53].

Let's consider the main characteristics.
The minimum dose of basal insulin per hour - the most important parameter, especially for children. The parameter shows what minimum dose of insulin the pump can enter in the basal mode for 1 hour. The lower the need for insulin - the smaller this step should be and the less units per hour the pump can enter, the better. Because the need for basal insulin during the day is different and there are cases when it is the addition of 0.02 units per hour that will help solve many problems.

Bolus insulin delivery step - shows the accuracy with which insulin can be injected to correct blood sugar when eating. The smaller the step is the better.

Automatic calculation of doses. Some pumps can calculate the recommended dose of insulin to correct blood sugar and food intake, and some may even consider the amount of active insulin - the residual amount of insulin after injection, which has a hypoglycemic effect. Dose calculation is based on the sensitivity coefficient, coefficient of meal, normal blood sugar level and active insulin time. Undoubtedly, with properly selected coefficients, the pump calculates quite adequate doses of insulin with accuracy to 0.1 units.

Bolus types - different modes of bolus insulin introduction- from different manufacturers, they have different names, but they have almost the same meaning.
– Normal (standard) bolus - all the insulin is administered immediately once.
– Double (multiwave) - part of a bolus is administered immediately; the rest is stretched for some time and delivered evenly during this time.
– Square (extended, elongated) - all dose of bolus is stretched for a certain time.

Sure, it's a very useful function, which may be required in different variants of food, digestive disorders, etc.

Number of basal intervals - indicating into how many time periods a day can be divided, each such interval can be specified its basal insulin dose. 24 intervals are quite enough.

Minimum length of a basal interval (minutes) - the parameter that follows directly from the previous one. If a pump has 24 intervals, the minimum duration of basal insulin is 60 minutes, which is quite enough for any patient.

Number of basal insulin profiles - shows how many variants of programmed basal insulin the pump can hold in its memory. This allows programming the basal intervals on different days / modes of life, if it is necessary. For example, one interval is for weekend, the other for weekdays.

Memory (days) – the parameter specifies the amount of information stored and available for analysis. Usually in the memory is stored more information than is available from the pump screen. Therefore it is useful to have the possibility to download the information to a computer.

Error Alerting System - all modern pumps are constantly in self-test mode and report various problems in functioning.

Measurement of blood sugar in real time - sugar measurement in real time and data output to the screen as a graph.
Button lock - automatic protection function from being accidentally pressed. All modern pumps have this function.
Communication with PC - how to download data from a pump to a computer - there are pumps with bluetooth, infrared port (IR), ComLink cable.

Water resistance - shows whether you can swim and take a bath with the pump.

Reservoir volume - shows how much insulin is placed in an insulin pump. The less insulin - the smaller the pump [54, 55].

In order to choose the right pump consumers should consider the following factors:
1. Small basal dose changes step in for young children (some pumps allow step of change of 0.025 or 0.05 units / hour, it is important at a small daily insulin dose).
2. Sufficient reservoir volume (this is particularly important for adolescents with a high daily dose of insulin).
3. Direct communication with a glucometer.
4. Alarms.
5. water resistance [56,57].

Today, an insulin pump is a particularly important opportunity to maintain an optimal level of glucose in the blood of children, adjusting it whenever needed at any time and without multiple insulin injections [58]. It should be noted that in children, particularly with well compensated diabetes there is a high risk of hypoglycemia, and they (unlike adults) may not always identify the symptoms of this condition. Since the pumps only use short-acting insulin (or its equivalent) and, if necessary, its introduction may be temporarily suspended, the use of pumps helps to solve the problem of timely prevention and elimination of hypoglycemia in children with diabetes mellitus (DM). Often there are problems from the need to introduce insulin to infants in very low doses - less than 0.5 units. In such cases the use of an insulin pump, which allows dosing the drug up to 0.01 units (so-called pump's step) is the only way to treat these children. Insulin dose and treatment regimen should be constantly adjusted in terms of the growing organism, lifestyle features and weight of the child's body. Another advantage of the pumps on the introduction of long-acting insulin in the traditional way using a syringe and injection pens is forming of its "depot" in the subcutaneous fat. This leads to nonuniform absorption and unpredictable fluctuations in the action of injected insulin. Using standard methods of glycemia research it is not always possible to choose the optimal mode of insulin administration, so the use of an insulin pump is the most effective in children and adolescents. Based on this can be assumed the future decrease in risk of late complications in children and adolescents with diabetes [59].

One of the many mistakes among patients when choosing pumps is misconception that insulin pump alone will calculate and enter a certain dose of insulin, for this reason many of them are not ready to count, adjust, program bolus and basal modes of the device. It is therefore necessary to conduct regular patient education of insulin pump therapy basics. It should be understood that strong motivation for compensation of diabetes significantly increases social adaptation of a patient in society [60].

Currently in Ukraine there is a problem with the lancets / insulin / syringes / test strips, as the state supplies the therapeutic and prophylactic institutions intermittently. The first school for training insulin pumps use was opened in March 2010 in a regional hospital in Dnepropetrovsk. According to statistics, 257 people in Ukraine officially use pumps, but it is known that in the U.S., many European countries, some regions of Russia, Kazakhstan, the state undertook the process of providing children with diabetes with pumps. In our country, the free provision of pumps and consumables is absent.

CONCLUSION

Diabetes today occupies unfortunately leading position among the diseases of the endocrine system, and only inferior to the prevalence of cardiovascular and cancer diseases. Modern medicine is not standing still, and today there is a good alternative to multiple injections - an insulin pump [61, 62].

Examining the global market revealed that the leading country in the production of insulin pumps is the United States. Among the most popular companies - manufacturers primacy take companies Medtronik and Sooil. Among the CIS countries by the number of pumps on the market Russia is the leader, but given the statistics, Ukraine is quite young and promising state in use of insulin pumps for the population.

The device has a number of advantages, but also it has drawbacks, including the cost of the pump. Despite this, the benefits of insulin pump prevail greatly, because there is no age limit for their use (they can be used from the age of 3 days and ending with patients older than 80 years); it is a device that allows more accurate insulin injecting basing on the individual needs at different times of day. It is an effective and convenient way of insulin delivery, when the aim of treatment is almost normal levels of glycemia. Pumps have a large number of functional modes, which allows patients to select the desired option, and the success of treatment depends on the motivation level, training of a patient and his further engagement in the process of self-control.

But consumers also should be extremely careful with the choice of the pump, as many of them believe that the pump is a method of curing diabetes. Thus, we have identified a wide range of features that will help consumers make the right choice [63,64].

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