

MODERN MEDICAL TECHNOLOGIES IN NURSING OBSERVATION OF METABOLIC DISORDERS – A CASE STUDY

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A. Study design/planning • B. Data collection/entry • C. Data analysis/statistics • D. Data interpretation • E. Preparation of manuscript • F. Literature analysis/search • G. Funds collection

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ABSTRACT

Introduction: Despite the traditional method of measurement of glucose in capillary blood in children, more and more often a continuous glucose monitoring system is used. Continuous glucose monitoring devices have been available to patients with diabetes for many years, and clinical trials have confirmed their effectiveness. The use of continuous glycaemic measurement allows us to increase the detectability of hypo- and hyperglycaemia. Hypoglycaemia in newborns and infants is a parameter that requires observation due to the circumstances that have an influence on the child's health and development.

Case description: The objective of this work is to show the usability of the continuous monitoring system using the Guardian RT system in nursing observation of an infant with hyperinsulinaemic hypoglycaemia. The study covered a 1.5-month-old infant who was hospitalised in the Clinic of Paediatrics, Endocrinology, and Diabetology in order to diagnose the cause of hypoglycaemia. In the research the method of a case study was used including the following methods: measurement, observation, interview, and document analysis.

Conclusions: The application and nursing supervision using a system of continuous glucose monitoring (CGM) in an infant revealed postprandial hypoglycaemia for up to two hours and even decreased glycaemia after taking the recommended milk mixture. The use of CGM allowed proper use of the genetic diagnosis of the child.

Key words: continuous glucose monitoring system, hypoglycaemia, hyperinsulinism.

INTRODUCTION

Metabolic disorders that show signs of hypoglycaemia are a serious problem for therapeutic teams. Until the third day after birth, hypoglycaemia is considered to be a temporary stage of the adaptation of a newborn's life. What is more, depending on the newborn's maturity and the presence of other pathologies, the threshold value of glycaemia is a highly individual parameter [1]. Hyperinsulinism is a rare cause of hypoglycaemia, which is revealed in newborn age (until 72 hours after birth), infant age (the disorders can appear between the first and twelfth month of life), and in the form of child hyperinsulinemic hypoglycaemia (after one year old) [2].

The safety of a child with hypoglycaemia and a rapid diagnostic process both require from the treatment team current monitoring of the child's glucose level. The basic tool of glycaemia control in the self-control and in screening tests is a glucom-

eter. The measurement of glycaemia by glucometer is invasive and, in the case of a small child, inconvenient and painful. Moreover, single measurements do not show the full picture of the changing glycaemia. The chance to monitor the changes, obtaining the results in real-time, analysing the archive results, and decreasing the quantity of punctures are advantages of a continuous glucose monitoring system. Modern devices, prepared especially for people with diabetes, are the perfect tool for nursing observation as well as in the diagnostic process of metabolic disorders.

The objective of this work is to show the usability of continuous glucose monitoring using the Guardian RT system in the nursing observation of an infant with hyperinsulinaemic hypoglycaemia.

MATERIAL AND METHODS

The study involved a 1.5-month-old infant who was hospitalised in the Clinic of Paediatrics, Endocrinology,

and Diabetology in order to diagnose the cause of hypoglycaemia. In the research the case study method was used as well as the following methods: measurement, observation, interview, and document analysis. In the case described in this paper, there was a need to obtain current information and make ongoing interventions, and the available device was a Guardian RT.

APPLICATION OF CONTINUOUS GLUCOSE MONITORING SYSTEM

Continuous glucose monitoring with the first monitoring devices started in the 1960s and '70s. The possibility to measure glycaemia and review the data in real-time was a turning point in diabetes treatment. However, initially, due to their large dimensions, the devices were stationary. In the following years, especially in the 1990s, the monitoring devices became smaller and more discreet. At the same time, they became less invasive and easier to use. Moreover, they provided precise and reliable measurements. Despite the systems of registration of data in real-time RT, i.e. the Guardian, patients finally had the system integrated with their private insulin pump (Paradigm 722, Veo, G-640) and also obtained devices that could register the measurement blinded (iPro), without the possibility of reviewing the data [3].

The device consists of an electrode, a transmitter, and a monitor, and it requires calibration, i.e. to enter a glucose measurement from a traditional glucometer. The system measures electricity in the extracellular liquid of the subcutaneous layer using a sensor (an Enlite type electrode) every 10 seconds and then every five minutes. The result is averaged and forwarded by a Mini Link transmitter to the Guardian or to another monitoring device as a digital value of the patient's glycaemia [4]. The patient undergoes 288 measurements per day, which can be reviewed on selected monitors in chosen hourly stages: at 3, 6, 12, and 24 hours. Apart from the glycaemia results, the transmitter sends to the receiver the trends of the glycaemia changes in the form of upward- or downward-pointing arrows. The device has the possibility of setting alarms according to the individual

thresholds for the values described as hypoglycaemia or hyperglycaemia. In such moments, the patient is notified by an alarm generated by the device, and thanks to this it is possible to implement the proper steps and avoid complications [5]. The blind method of monitoring glycaemia is used for diagnostic measurements for patients who do not need any current corrections, e.g. in diagnosis of diabetes in patients with mucoviscidosis.

CASE DESCRIPTION

A 1.5-month-old infant (male) was hospitalised in the Clinic of Paediatrics, Endocrinology, and Diabetology in order to diagnose endocrinological and metabolic disorders which were characteristic of hypoglycaemia. The boy was born in the 40th week of a second pregnancy by Caesarean with macrosomia and after-birth caseation danger. The weight of the boy was 4850 g, and his overall condition was described as average. In the Apgar scale he scored: 1 min – 5 points; 3 min – 7 points; 5 min – 8 points; and 10 min – 8 points. After the decompression breath he received passive oxygen therapy with FiO₂ from 0.3-0.4 l/min. The initial result showed high leukocytosis (55.77 thousand) and low glycaemia (< 0.28 mmol/l), supported by antibiotic therapy, empirically associated to get negative results of the screening tests of blood and cerebrospinal fluid (PMR – CSF). The child had a weak suction reaction, was fed by mother's milk using a probe and then by a pacifier, and was under the supervision of a physiotherapist in order to stimulate suction reaction and for overall rehabilitation. In the neurological assessment the following disorders were recognised: axial limpness, and decreased tonicity of the lower limbs and oral area. There were no changes in MRI of the head and brain.

The child was directed to the Clinic of Paediatrics, Endocrinology, and Diabetology due to hypoglycaemia and a suspicion of hyperinsulinism. In the Clinic the infant's level of glucose was observed, and the supervision revealed hypoglycaemia. Due to the need to observe the changes of glycaemia and the parents' concern about their child, it was decided that the glycaemia would be constantly monitored using a Guardian RT GCMS device. The parents' consent was obtained, they were trained, and then an Enlite type electrode was applied. After introduction of the first calibration, access to constant measurements was obtained.

In the conducted test of starving the following was obtained: glycaemia 29 mg/dl and insulin level 8 mU/l. On the other days, hypoglycaemia was observed at a level of approximately 37 mg/dl with accompanying convulsions. Due to suspicion of galactosaemia, it was decided to abandon mother's milk and start feeding by Nutramigen instead. At the same



Figure 1. Guardian RT system (source: manufacturer's materials, used with permission)

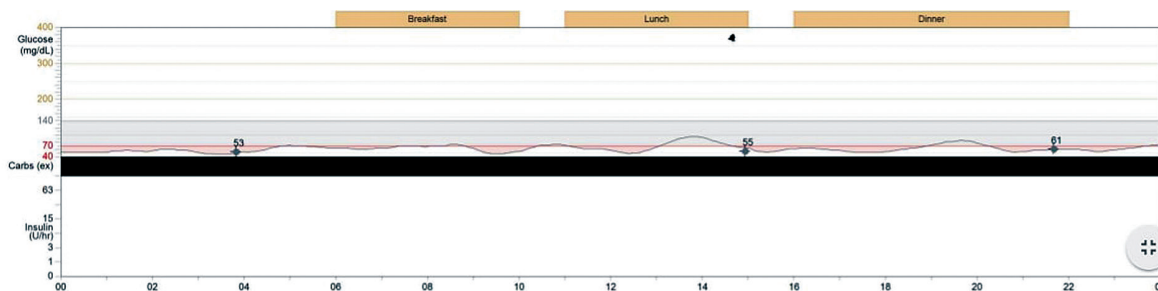


Figure 2. Individual results of our patient (developed using CareLink Medtronic software)

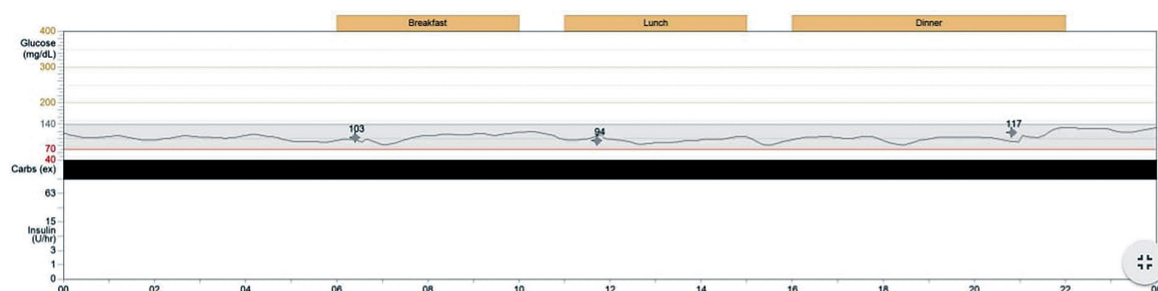


Figure 3. Individual results our patient after implementation of Nutramigen (developed using CareLink Medtronic software)

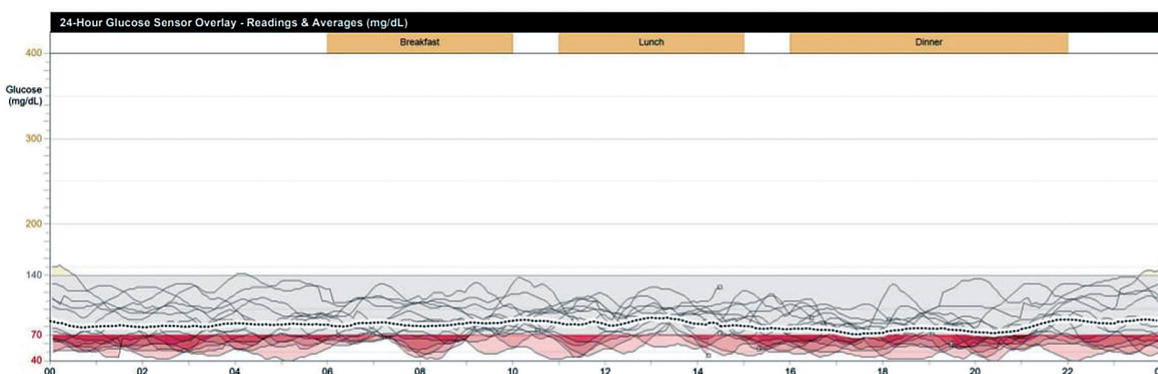


Figure 4. Individual results of our patient after implementation of Bebiko 1 and Fantomalt (developed using CareLink Medtronic software)

time, samples to diagnose galactosaemia were taken (Beutlera-Baludy test). The glycaemia and intervals between feedings were constantly monitored. Post-prandial glycaemia was particularly closely observed and analysed. The observation of glycaemia after taking the mixture, in the time frame up to two hours, showed an absence of the expected improvement of glycaemia after feeding, and even a decreased level of glycaemia after feeding with Nutramigen milk. The observations from constant monitoring of glycaemia in real-time and tracking the previous records persuaded the therapeutic team to find a cause of hypoglycaemia other than galactosaemia and abandon the use of Nutramigen. A diet based on Bebiko 1 with the addition of Fantomalt was implemented, which helped to obtain better glucose concentration.

RESULTS

The results of the measurement of glycaemia value in the infant during treatment and feeding by mother's milk and Nutramigen mixture were as follows: 53-48-53-37-40-43 mg/dl and 45-48-57-51-38-96-103-70-76-87-66-78-58 mg/dl. After implementation of Bebiko 1 with the addition of Fantomalt mixture, the infant had glycaemia as follows: 102-69-112-84-70-82-125-122-103 mg/dl.

Further diagnostics were directed towards the Beckwith-Wiedemann syndrome. After the hospitalisation the infant's parents still wanted to use the system of constant glycaemia monitoring to check the changes and to implement early interventions in the case of decreasing tendencies.

The infant was directed to genetic examination, which confirmed the occurrence of inherited metabolic disease on the basis of mutation in hyperinsulinism gene BCC8 c.3992-9G>A, which, along with the clinical review, allowed identification of hyperinsulinaemic hypoglycaemia. Methylation disorders characteristic for Beckwith-Wiedemann syndrome were not confirmed.

DISCUSSION

The determinant of hypoglycaemia among the children is a decrease in glucose that exposes them to potentially dangerous consequences. The threshold value among children is considered as a concentration of glucose below 65 mg/dl; severe hypoglycaemia is recognised when convulsions and loss of consciousness occur. Immediate intervention – with intravenous application of glucose – requires glycaemia 45 mg/dl and below [6]. The research regarding disorders of activity of the brain and neurological effects of hypoglycaemia among children with diabetes ambiguously estimate the influence of returning severe hypoglycaemia on cognitive functions, long-lasting memory, attention, and intelligence quotient of such children. Some of the researchers demonstrated an essential influence of hypoglycaemia on brain disorders, while others suggested a lack of differences or very small changes, especially when diabetes and hypoglycaemias concerned small children under six years old [7]. In research conducted among children without diabetes it turned out that severe hypoglycaemia is harmful for the brain structures and disorders in motoric development, especially when hypoglycaemia emerges in the first days of life. The long-lasting states of hypoglycaemia with its high intensity cause damage to the corticospinal, parietal, and occipital parts of the body with the possible risk of development of epilepsy [8]. Another important consequence of hypoglycaemia in the early stage of development can be lost secretory capacity of Langerhans islands at a later age. Hypoglycaemia that lasts up to 48 hours is a temporary physiological state, but when it lasts for more than 2-3 days of life, it requires rigorous diagnostics. The endocrinological causes of hypoglycaemia among newborns can be caused by temporary or permanent hyperinsulinism, disorders of carbohydrate-metabolism, amino acid, fatty acids, and endocrine disruption. The occurrence of in-born hyperinsulinism is assessed as 1/50,000 live births. In about 80% of cases, determination of the disorder is successful [6]. The genetic disorders can concern the 10th or 11th chromosome. In the described case in an infant, the disorders concern the 11th chromosome, and more precisely the function of the potassium channels and constant exudation of insulin [9]. The incorrect treatment of in-born hyperinsulinism

is a cause of very serious developmental disorders in over 50% of such children. Apart from the monitoring of the glycaemia, preventing severe states of hypoglycaemia among children with metabolic disorders, the important thing is to make a quick and accurate diagnosis and rapidly implement treatment and monitoring of the patient's health. The suspicion of galactosaemia, implementation of the treatment with exclusion of lactose, and strict observation of the lack of the effect of the implemented treatment allow (even before getting the result of the Beutlera-Baludy test) new causes of hypoglycaemia in infants to be found.

The final recognition in the described situation of the infant is a mutation in the hyperinsulinism gene, and the case of the infant was included in other research in Great Britain. Especially worthy of note is the fact that including constant monitoring of glycaemia and the ability of observation for the therapeutic team allowed the implementation of directed and accurate diagnostics and proper treatment.

Incorporation of a continuous glucose monitoring system for observation of an infant with signs of hyperinsulinaemic hypoglycaemia allows the following:

- decreasing the number of punctures of the finger to just 2-3 per day (necessary for system calibration);
- obtaining a considerable number of results of glycaemia measurement in a non-invasive way – 288 measurements;
- insight into glycaemia value in real-time;
- access to previous glycaemia records;
- undertaking early interventions that help to avoid severe hypoglycaemia and consequences of hypoxic and ischaemic encephalopathy;
- providing in nursing observation more relevant data about the patient's state of health and contributing to improvement of the quality of the parents' life.

CONCLUSIONS

The inclusion of a continuous glucose monitoring system enabled rapid implementation of targeted diagnostics and adequate treatment.

The decision to use a continuous glucose monitoring system in an infant minimised the frequency of pain and anxiety associated with the frequent punctures necessary for glucometer glucose measurement.

The use of a continuous glucose monitoring system allowed a very large number of measurements to be obtained and the possibility of their analysis in relation to the child's condition.

There is a need to improve paediatric nurses' knowledge regarding rare diseases in childhood, which are characteristic of infant hypoglycaemia (disorders of carbohydrate-metabolism, amino acid, fatty acids, in-born endocrine disruption, and others).

In the case of hospitalisation of a child with metabolic disorders and signs of hypoglycaemia, supervision of the child is a necessity, by using the most modern and available devices that monitor glycaemia level. Also important is the possibility to recreate current results of the measurements and to read results from the patient's history, monitoring the trends and charts of glycaemia and using alarm systems.

Disclosure

The authors declare no conflict of interest.

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