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Emergency medical conditions in diabetes – prehospital procedure

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Abstract

Diabetes, as the chronic disease of the XXI century, constitutes a significant challenge for health care systems in the whole world. This disease which is referred to by some researchers as an epidemic, generates very high costs of treatment. Despite of remarkable progress in the diagnostics and treatment, emergency conditions in diabetes still constitute a threat to the health and life of the ill person. Chronic hyperglycemia is associated with the dysfunction and damaging of many internal organs for example: the damaging of eyes – retinopathy, of kidneys – nephropathy, of blood vessels – angiopathy. Hypoglycemia resulting from the excessive amount of insulin in reference to the organism's demand is frequently the cause of summoning Medical Rescue Teams. If it occurs with a loss of consciousness it requires immediate treatment and its complications in the form of brain edema require further hospitalization. Ketoacidosis is characterized by a high concentration of glucose, electrolyte disorders and abnormalities in the acid-base economy. The appropriate procedure of the staff of medical rescue teams in emergency situations in case of diabetes at the place of the incident reduces the amount of complications during hospitalization. *Anestezjologia i Ratownictwo 2018; 12: 279-286.*

Keywords: diabetes, medical rescue team, medical procedures, glucose

Introduction

One of the urging health problems is the increasing epidemic of diabetes, the incidence of which is going to grow by 55% by the year 2035. According to the data of the International Diabetes Federation, in the whole world, every 10 seconds diabetes manifests itself in 3 new persons, which gives the number of nearly ten million cases per year. The number of people with type 2 diabetes in Poland is currently estimated to be nearly 2 million, of which only about 50% are cases of diagnosed diabetes. The too late diagnosing of this disease results in the development of late complications of diabetes which, together with the costs of treatment, constitute a huge burden on the health care systems [1,2]. Acute complications of diabetes which may have a dynamic course, constitute a life-threatening condition and their diagnosing and treatment is a challenge for the medical

staff providing care to the patients in prehospital and early hospitalization conditions. The aim of the paper was describing the most frequent emergency medical conditions in diabetes together with the currently applicable prehospital procedure.

The regulation of the glucose concentration in the organism

Appropriate regulation of the biochemical processes occurring in the human organism as well as maintaining physiological functions requires supplying energy [3]. Its main source are carbohydrates which, together with proteins and fats, constitute the basic component of a proper diet. The main functions of carbohydrates in the organism include participation in chemical and energetic transformations which are referred to as metabolism. The majority of carbohydrates delivered together with food are hexoses, the most important of which are glucose, galactose and fructose. Their absorption occurs in the duodenum and in the upper section of the jejunum; the main product of their digestion and the main sugar circulating in the blood is glucose [4,5].

In homeostasis the glucose blood level is maintained in relatively narrow limits at the level of ca. 4.5-9.0 mmol/l (81-162 mg/dl) [6]. In mechanisms responsible for avoiding both the lowering as well as the excessive increasing of the glucose blood concentration the key role is played by hormones. Glucose concentration is increased by glucagon, adrenaline, noradrenaline, glucocorticosteroids. Hormones responsible for lowering the glucose level are insulin and amylin (which supplements the effect generated by insulin) [7,8]. Out of the listed hormones, the most important roles are played by insulin and glucagon. These hormones are secreted in the islets of Langerhans located in the pancreas. Insulin, which is a protein, is the main anabolic hormone secreted in response to the increasing of glucose concentration in the blood and its main function is controlling the glucose concentration. Glucagon is produced by the α cells of the pancreas. It's main function is based on antagonizing the action of insulin and maintaining the correct blood concentration of glucose through initiating the rapid increase of endogenous glucose production carried out by the liver in the process of glicogenolysis [4,8,9]. In homeostasis conditions the blood concentration of glucose is maintained in correct limits thanks to the proper insulin secretion performed by the β cells of the pancreatic islets of Langerhans and the appropriate tissue sensitivity to insulin. The disruption of the balance of carbohydrate metabolism is associated with the occurrence of several processes among which it is above all necessary to mention the autoimmune destruction of the pancreas β cells, the consequence of which are abnormalities in the secretion of insulin and disorders leading to the insulin resistance of cells. The deficiency of insulin is accompanied by the pathological concentration of hormones acting to the opposite, i.e. the growth hormone, catecholamines and above all glucagon, which – in combination with an inappropriate diet, obesity and a lack of physical effort leads to disruptions of proper metabolic processes. The consequence is the occurrence of diabetes which, in accordance with the definition of the WHO, is a group of metabolic diseases characterized by a chronic elevated blood glucose level, i.e. hyperglycemia [10-12]. Long-term hyperglycemia leads to the dysfunction, damaging and failure of many organs and causes the occurrence of retinopathy with the potential loss of sight; nephropathy leading to renal failure, peripheral neuropathy with the risk of ulcers and limb amputation and autonomous neuropathy causing symptoms from the side of the digestive system, the urogenital system together with sexual dysfunction. Elements which also need to be included in this group are changes in the circulatory system which, due to the acceleration of atherosclerosis lesions, may lead to the occurrence of the coronary heart disease, strokes, peripheral vascular diseases and hypertension [11-13].

The currently applicable classification of diabetes was announced in 2003 by the American Diabetes Association (ADA) and the World Health Organization (WHO). In 2003 these entities presented an etiologic classification of diabetes differentiating four types of this disease.

Type 1 diabetes is a disease occurring in 5-10% of persons with diabetes [11]. The most frequent patients are above all children, adolescents and the so called young adults, in 85-90% of cases it is associated with children and persons younger than 30; in 10-15% it is associated with elderly people. The most frequent cause of its occurrence is absolute insulin deficiency resulting from the destruction of over 80% of the β cells of the pancreas. The natural development of type 1 diabetes occurs in three phases. The first two of them include the preclinical period – the so called *prediabete*s. The first phase is asymptomatic, however it may be diagnosed

thanks to determining the sequence of genes predisposing to the development of the disease. In the second phase certain environmental factors activate processes which are responsible for the destruction of the β cells of the pancreas, the releasing of autoantibodies and inflammatory factors as well as the impairment of insulin secretion. The subsequent third phase of the disease is the period of overt diabetes during which the endogenous insulin reserves become depleted and the clinical symptoms of the disease become visible [14]. Typical symptoms of type 1 diabetes are: polyuria, increased thirst (polydipsia), increased hunger (polyphagia), body mass reduction and the tendency to ketosis and ketone coma [15].

Type 2 diabetes most frequently occurs in persons aged over 55 and it occurs in 10-15% of persons aged above 65 [15]. If we add to this group the 25-30% of the population of this age who are diagnosed with an elevated glucose blood level which does not achieve values typical for diabetes yet, it is possible to conclude that nearly a half of the persons aged above 65 have got problems with carbohydrate economy leading to the occurrence of diabetes. A sudden beginning of this type of disease occurs only in 15% of patients. In case of 85% of patients the beginning of the disease is imperceptible. In about 50% of patients the consequence of the hidden development of the disease is the occurrence of specific diabetes complications in late disease stages, these complications include: recurrent furunculosis, gangrene of the foot, neuralgia, visual disturbance, vulvar pruritus; these complications constitute the clinical picture of the disease [15]. In the pathogenesis of type 2 diabetes there is the coexistence of two basic pathophysiological defects which include the impairment of insulin secretion and the decrease of the sensitivity to this hormone in peripheral tissues such as: skeletal muscles, the hart, the liver, adipose tissue and others [16]. The development of this type of diabetes in the initial period is related to the increasing process of insulin resistance, the consequence of which is the attempt of the pancreatic islets beta cells to compensate this phenomenon through the increased production of insulin. These changes cause increasing disorders of the function of the beta cells, the consequence of which is the occurrence of hyperglycemia. The development of type 2 diabetes may for many years take place as the so called pre-diabetes condition or occur without clear, classic symptoms such as: increased thirst and polyuria, blurred sight and losing weight. That is why the disease is frequently diagnosed by accident, during periodic health examinations or examinations performed due to the occurrence of some other disease [15-17]. Category III of the diabetes division carried out according to the WHO, referred to as "other specific types of diabetes", includes the forms of the disease which do not correspond with the above described types of diabetes and are caused by numerous genetic defects of the beta cells activity and the action of insulin. This division includes secondary forms of diabetes which develop as results of diseases which damage the pancreas parenchyma, as a result of inflammations, injuries, cancer, cystic fibrosis or hemochromatosis as well as forms of diabetes resulting from endocrinopathy [18,19].

Gestational Diabetes Mellitus is diagnosed in case of the occurrence of metabolic disorders emerging in pregnant women who had earlier been healthy. During pregnancy, especially in the second and third trimester there is a physiological reduction of sensitivity to insulin and a deterioration of glucose tolerance caused by a significant increase in the level of hormones such as: placental lactogen, prolactin, the luteinizing hormone, human chorionic gonadotropin, progesterone, glucagon and cortisol. The diabetogenic effect of these hormones results in the decrease of glucose tolerance, the increase of insulin resistance, the reduction of the glycogen reserve and increased gluconeogenesis in the liver. In diabetes of this type we distinguish diabetes occurring in the female patient irrespectively of the pregnancy, which is diagnosed thanks to the intensified physician's care over the pregnant women and Gestational Diabetes Mellitus – disorders of glucose metabolism caused by the pregnancy which cease spontaneously after the labor. Not introducing treatment against Gestational Diabetes Mellitus may lead to many abnormalities in the mother in the form of arterial hypertension, an urinary infection, hydramnios; the consequence of these disorders may be miscarriage, preeclampsia or eclampsia or premature birth. The consequences related to the fetus include increased risk of the occurrence of macrosomia, hypotrophy, congenital defects of the tubular heart and the kidneys as well as stillbirth. The group of increased risk of the occurrence of diabetes during pregnancy includes women at an advanced age, obese women, women with glucosuria and with a pregnancy with hydramnios. Moreover, an incident of Gestational Diabetes Mellitus is a risk factor for the development of type 2 diabetes after 15-20 years [12,14]. Besides the basic division of

diabetes it is also necessary to mention two forms of the disease which – due to the frequency of occurrence and therapeutic difficulties – are of particular importance. These are LADA diabetes (*latent autoimmune diabetes in adults*) and MODY diabetes (*maturity onset diabetes of the Young*) [12,14].

Emergency medical conditions in diabetes mellitus

The prevalence of diabetes in Poland is estimated to be over 2 million cases. The increasing incidence of both type 1 and 2 diabetes results in the necessity to ensure that the medical staff are familiar with the basic information relating to the acute complications of diabetes which are a direct life-threatening condition. Acute complications of diabetes may occur at any time and their course may be very dynamic. They include: hypoglycemia, ketoacidosis, the hyperglycemic-hyperosmolar syndrome and lactic acidosis.

Hypoglycemia

Hypoglycemia constitutes the most frequently occurring acute complication of diabetes. The occurrence of severe hypoglycemic incidents among patients treated with insulin is 23 out of 1000 patients per year whereas the mortality is estimated to be 2-4% [20,21]. In accordance with the recommendations of the Polish Diabetes Association and the European Medicine Agency hypoglycemia is recognized in case of the venous blood serum glucose concentration below 55 mg/dl (3.1mmol/l) irrespectively of the occurrence of clinical symptoms [22]. The reasons for hypoglycemia which is the result of an excessive amount of insulin in the organism may be missing a meal or having a meal which is too small, overdosing oral hypoglycemic drugs or insulin, increased physical effort without the supplementation of calorie losses, drinking alcohol. Other risk factors are: elderly age, intense insulin therapy, diseases affecting the metabolism of glucose or of hypoglycemic drugs [20,21]. The decreasing blood level of glucose may be accompanied by the occurrence of typical clinical symptoms including symptoms which are the consequence of the increased activity of the sympathetic system as well as neuroglycopenic symptoms. During the occurrence of mild hypoglycemia the initial symptoms are hunger, weakness, limb tremors, anxiety, increased sweating, dilation of the pupils, tachycardia and increased blood pressure, paleness of skin. When the glucose concentration decreases to a value of about 50 mg/dl the symptoms of neuroglycopenia become additionally present. They result from the decreased supply of glucose to the brain which shows high sensitivity to hypoglycemia. These symptoms include the impairment of cognitive functions, confusion, lethargy, convulsions and the loss of consciousness [19-21].

The above symptoms may be the sign of many other diseases therefore in the clinical differentiation it is necessary to take into consideration conditions and disorders such as alcohol abuse, epilepsy, stroke, electrolyte disorders, depression and psychosis, overdose of sympathomimetics, liver or kidney failure (table I) [19].

The prehospital procedure should depend on the glycaemia level in venous blood, the advancement of hypoglycemia symptoms and on the state of consciousness disturbances. In case of mild and moderate

Table I. The causes, symptoms and differentiation of hypoglycemia

HYPOGLYCEMIA		
CAUSES	**SYMPTOMS**	**DIFFERENTIATION**
taking a too high dose of an antidiabetic drug administering a too high dose of insulin missing a meal excessive physical effort alcohol abuse	feeling of hunger abundant sweating muscular tremor paleness of skin feeling of heart pounding anxiety, irritability dizziness and headaches disturbances of speech and sight difficulties in associating impaired sensation convulsions agitation, aggression loss of consciousness, coma	epilepsy stroke electrolyte disorders depression psychosis renal failure liver failure alcohol poisonings

hypoglycemia a conscious patient should receive simple carbohydrates in the form of meals or drinks containing them or 10-20 g of glucose in the form of tablets or gel which is going to result in the increase of the glycaemia level after about 10-20 minutes. In case of the occurrence of disturbances of consciousness or the loss of consciousness it is necessary to administer a 20% glucose solution (0.2 g of glucose/kg of body mass) intravenously. In case of difficulties in accessing veins it is necessary to consider administering 1 mg of glucagon (0.5 mg in case of children aged under 6) intramuscularly or subcutaneously remembering that this drug is ineffective in case of damage to the liver parenchyma, in case of long-term starvation and in alcoholics [19,22,23],

An incident of severe hypoglycemia should finish with the hospitalization of the patient in case of the occurrence of symptoms of brain edema, the persistence of disturbances of consciousness after achieving the normalization of the glycaemia, injuries resulting from the loss of consciousness, the risk of the recurrence of severe hypoglycemia, e.g.: after overdosing long acting insulin (table II). An indication for hospitalization is also the patient's age lower than 2 and the occurrence of another severe hypoglycemia incident in the period of the last 2 years [20].

Diabetic ketoacidosis

Ketoacidois is an acute syndrome of disorders of the metabolism of carbohydrates, fats, proteins and of the water-electrolyte and the acid-base balance occurring as a result of a sudden and significant deficiency of insulin. Currently it is estimated that the mortality does not exceed 5% however it is higher among elderly persons and persons with recurrent episodes of acidosis [23,24]. Characteristic features of ketoacidosis are the occurrence of hyperglycemia, metabolic acidosis, excessive production of ketone compounds, protein hypercatabolism and significant dehydration which may lead to a hypovolemic shock [19].

The most frequent reasons for the occurrence of ketoacidosis are mistakes in insulin therapy or its discontinuation, acute pancreatitis, alcohol abuse, infections, cerebrovascular events and myocardial infarction. The lack of insulin in the organism and the increase of the concentration of hyperglycemic hormones lead to hyperglycemia and dehydration. At the same time the organisms starts to burn fats and muscle tissue which results in the creation of ketone bodies which lead to blood acidification and in consequence – to coma. The clinical picture depends on the patient's age, the duration and the pace of increase of hyperglycemia and the presence of chronic complications of diabetes. Characteristic symptoms are: hyperglycemia exceeding 250 mg/dl, a loss of appetite, polyuria which may amount to several liters per day, symptoms of dehydration (dry tongue and skin), reduction of blood pressure. In developed ketoacidosis a frequent symptom are ailments from the side of the digestive system, i.e. nausea, vomiting, stomach ache. A characteristic symptom from the side of the respiratory system is accelerated Kussmaul breathing which may be accompanied by the smell of acetone sensible in the exhaled air. From the side of the nervous system we can observe disturbances of consciousness and coma [19,20,24].

The treatment of diabetic ketoacidosis at the prehospital stage should include fluid therapy. During the first hour it is recommended to administer 1000 ml of a 0.9% NaCl solution and during 24 hours another 500 ml per hour with controlling the patient's circulatory system efficiency parameters and his/her clinical con-

Table II. Prehospital procedure in case of the occurrence of hypoglycemia

THE TREATMENT OF HYPOGLYCEMIA	
MILD AND MODERATE HYPOGLYCEMIA	**SEVERE HYPOGLYCEMIA**
A conscious patient able to swallow liquids and food: administering 10-20 g of glucose intake of complex carbohydrates	An unconscious patient or a person with disturbances of consciousness: intravenous administration of a 20% solution of glucose (0.2 g of glucose/kg of body mass) in case of difficulties in accessing veins 1 mg of glucagon (0.5 mg in children aged < 6) intramuscularly or subcutaneously intake of complex carbohydrates

Table III. Prehospital procedure in case of the occurrence of diabetic ketoacidosis

DIABETIC KETOACIDOSIS	
CAUSES	**SYMPTOMS**
mistakes in insulin therapy discontinuation of insulin therapy acute pancreatitis alcohol abuse infections myocardial infarction	hyperglycemia above 250 mg/dl loss of appetite polyuria symptoms of dehydration lowering of blood pressure nausea, vomiting, stomach ache Kussmaul breathing smell of acetone disturbances of consciousness, coma
TREATMENT	
fluid therapy – transfusing 6-10 l of fluids in 24 h reducing the hyperglycemia – intravenous administration of insulin treatment of electrolyte disorders – potassium, , sodium bicarbonate treatment of the cause of ketoacidosis	

dition. The next stage is reducing the hyperglycemia by administering crystalline insulin (short acting) in the form of a single dose of 8-10 units administered intravenously. Next, in a drip infusion the patient should receive insulin doses allowing for lowering the glycemia by 50-70 mg/ml/hour. The treatment of ketoacidosis also requires the normalization of the deficiency of potassium which is shifted to cells. For patients with normokalemia the recommended dose is 20mEq KCl per liter of liquids and for patients with hypokalemia the dose is 40 mEq/l. In a situation when the value of the arterial blood pH is below 7.0 it is recommended to administer an ampoule of sodium bicarbonate in 500 ml of a 5% solution of glucose. Moreover it is necessary to search for other factors which may induce the occurrence of diabetic ketoacidosis, e.g.: an infection, myocardial infarction, a burn, pneumonia (table III). Most therapies are feasible in hospital conditions therefore the patient needs to be transported to the appropriate hospital [19,22-24].

The hyperglycemic hyperosmolar syndrome

The hyperglycemic hyperosmolar syndrome mainly occurs as a complication of type 2 diabetes in persons with a partial insulin deficiency accompanied by disorders related to thirst regulation and thus a significantly limited fluid intake. Disorders of this type are intensified by the consuming of large amounts of alcohol and by using some diuretics. The symptoms develop in a period of from a few days to a few weeks.

Table IV. Prehospital procedure in case of the occurrence of the hyperglycemic hyperosmolar syndrome

HYPERGLYCEMIC HYPEROSMOLAR SYNDROME	
CAUSES	**SYMPTOMS**
delayed diagnosing or inadequate treatment of type 2 diabetes stroke myocardial infarction alcohol abuse chronic nephritis use of diuretics infections, diarrhea, vomiting	- hyperglycemia above 600 mg/dl - loss of appetite - polyuria - loss of body mass - symptoms of dehydration - disturbances of consciousness - coma
TREATMENT	
fluid therapy – transfusing 6-10 l of fluids in 24 h reducing the hyperglycemia – intravenous administration of insulin treatment of electrolyte disorders – potassium, , sodium bicarbonate treatment of the cause of the hyperglycemic hyperosmolar syndrome	

Table V. Prehospital procedure in case of the occurrence of lactic acidosis

LACTIC ACIDOSIS	
CAUSES	**SYMPTOMS**
type A cardiogenic shock, severe hemorrhages, acute sepsis and chronic respiratory failure type B causes other than hypoxia Occurs in patients with diabetes, with liver diseases, medications: salicylate, biguanides	weakness moderate dehydration nausea, vomiting, stomach ache polyuria Kussmaul breathing disturbances of consciousness hipotension, shock, hypothermia
- fluid therapy – transfusing 6 – 10 l. of fluids in 24 h - reducing the hyperglycemia – intravenous administration of insulin - treatment of electrolyte disorders – potassium, , sodium bicarbonate treatment of the cause of lactic acidosis	

Intensifying hyperglycemia leads to progressive dehydration. There are big electrolyte abnormalities, the osmolar concentration of the plasma increases and frequently also pre-renal kidney failure occurs. The characteristic symptoms include hyperglycemia above 600 mg/dl, polyuria, lack of appetite, body mass loss, features of dehydration including hypovolemic shock and – more frequently than in ketoacidosis – disturbances of consciousness and coma. The mortality is high and amounts to 15%. The course of prehospital treatment follows the same recommendations as those for diabetic coma caused by ketoacidosis (table IV) [19,20,23,24].

Lactic acidosis

Lactic acidosis (type B) caused by the excessive accumulation of lactic acid in the organism, unlike the previously mentioned diseases, is not a complication typical for diabetes. It develops mainly in type 2 diabetes as a result of the use of drugs belonging to the group of biguanides (oral antidiabetic drugs) if the following contraindications are not taken into consideration: renal failure and states of tissue hypoxia. The symptoms of lactic acidosis develop suddenly, within a few hours. Patients report ailments from the side of the digestive system, i.e. stomach ache, nausea, vomiting, diarrhea. Features of dehydration and extreme exhaustion may also be diagnosed. Symptoms which also occur are tachycardia, Kussmaul breathing, lowering of the arterial pressure and disturbances of consciousness. Lactic acidosis may also be accompanied by the symptoms of disorders responsible for its occurrence e.g. myocardial infarction, a large hemorrhage, pneumonia, which have to be treated in accordance with needs.

The treatment, similarly as in previously mentioned conditions related to hyperglycemia, requires the administration of 1000 ml of 0.9% of the NaCl solution within the first hour. In order to restore the appropriate volume of the vascular bed. In order to avoid hypoxia 100% oxygen must be administered to the patient and in case of need it is necessary to apply breathing support. In order to reduce the glycemic level it is necessary to perform an intravenous drip infusion of insulin with a pace of 0.1 unit/kg of body mass/hour in an appropriate combination with a 5% solution of glucose. In patients with an arterial blood pH level below 7.0 it is recommended to administer an ampoule of sodium bicarbonate in 500 ml of a 5% solution of glucose (table V) [19,20,23].

Conflict of interest
None

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