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Faculty international

*(faculty name)*

Department of Pediatrics

*(name of department)*

APPROVED
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# METHODICAL RECOMMENDATION FOR THE LECTURE FROM THE EDUCATIONAL COMPONENT

Faculty international, course 5_____

Educational component - "PEDIATRICS"

_____

*(name of the educational discipline)*

## Topic 3: Diabetes mellitus in children

Approved:
Meeting of the Department of Pediatrics

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**Note.** In the case of publication of methodological recommendations as an independent printed work, the academic council of the faculty provides a recommendation for publication in the presence of two reviews, one of which is external — from a reviewer of another institution of higher education.

Lecture №3

## Topic: Diabetes mellitus in children

**Defining the learning goal.** Diabetes mellitus (DM) - a disease characterized by hyperglycemia, which is the result of defects in insulin secretion, insulin action or both. Background is determined by the following factors: - a large number of patients in both adults and in childhood; - the trend of the disease in infancy in recent years; -an early disability of patients; - need for the therapy continuously throughout life; - development of severe complications (coma, angiopathy, etc.); -children suffering from the first type of diabetes that requires insulin every day throughout life.

The prevalence of diabetes among the world's population is 2 - 3%. Of the total number of patients with diabetes children are 5-8%. The frequency of diabetes in pediatric population - 1 in 500 children and adolescents. The disease occurs at all ages, including infancy, but more often diagnosed in the period of most intensive growth - 5-8 and 11-15 years.

In recent years there has been a tendency to increased frequency of the DM debut at an early age. The structure, diagnostic methods and treatment strategy of diabetes in children has changed recently. It is very important for pediatricians and family practice physicians to diagnose and to prescribe effective therapy in time, to prevent the disease and to conduct rehabilitation.

At the present stage, the structure, methods of diagnosis and treatment of diabetes in children have changed. It is very important for a pediatrician and family doctor to diagnose in time and prescribe effective therapy, to carry out rehabilitation methods for the prevention of heart disease.

**Purpose**: to acquire knowledge about diabetes in children, to determine the features of the course of the disease, to get acquainted with the principles of treatment and diagnosis of diabetes in children.

**Basic concepts:** diabetes in children: definition, etiology, pathogenesis, classification, clinic, diagnosis, differential diagnosis, treatment, prevention, prognosis. Acute and chronic complications of diabetes in children. Hyperglycemic ketoacidotic and hypoglycemic coma in children: causes, pathogenesis, clinic, diagnosis, differential diagnosis, emergency care, prevention.

**Plan and organizational structure of the lecture.**

1. Definition of DM.
2. Etiopathogenesis of DM.
3. Classification of DM.
4. Clinical features of DM.
5. Acute and chronic complications of DM.

6. Laboratory diagnostics of DM.
7. Differential diagnosis of DM.
8. Treatment of diabetes of DM.
9. Prevention of diabetes of DM.

**Content of lecture material**.

**1. Definition.** Diabetes mellitus (DM) is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The name of the disease comes from the Greek "diabaino" - to pass through. A condition that develops as a result of the destruction of b-cells of the pancreas, followed by absolute insulin deficiency, is defined as type I diabetes, which is the dominant form of this disease in children.

The prevalence of DM among the world population is 2-3%. Children make up 5–8% of the total number of patients with diabetes. The frequency of diabetes in the pediatric population is 1 case per 500 children and adolescents. The disease occurs in all age periods, including infancy, but is more often diagnosed in the periods of the most intense growth - 5–8 and 11–15 years. In recent years, there has been a trend towards an increase in the frequency of diabetes onset at an early age.

Genetic predisposition plays an important role in the prevalence of diabetes. Among the genetic markers of predisposition to diabetes, the most studied are the major histocompatibility complex (HLA) genes, among which DR3, DR4, B8, B15, B18 are more often expressed in patients with diabetes. Provocative risk factors contributing to the manifestation of diabetes are excessive food consumption (especially with a high content of carbohydrates, which reduces glucose tolerance), infectious viral diseases, mental and physical injuries.

**2. Etiopathogenesis**. In the context of modern views on the development of the most common diseases in the general population, DM represents a biopsychosocial pathology with a multifactorial polygenic nature of development and inheritance. Type I diabetes (or insulin-dependent diabetes mellitus, IDD) is considered an autoimmune process that develops against the background of genetic predisposition under the influence of environmental factors. Possible mechanisms of hereditary predisposition to IDD are increased sensitivity of ß-cells of the pancreas to viral antigens, weakening of antiviral immunity and susceptibility to autoimmune damage to the insular apparatus of the gland. The immunopathological process that leads to the development of ICD begins years before the clinical manifestation of the disease. Rubella, chicken pox, mumps, and Coxsackie viruses are considered as trigger factors. These viruses bind to the receptors of Langerhans cells and stimulate the synthesis of antibodies to the endocrine apparatus and insulin. The stage of chronic autoimmune insulitis leads to partial destruction of ß-cells, which is accompanied by a decrease in insulin secretion when carbohydrates are

consumed (introduction of glucose), but fasting normoglycemia remains. In the further course of the pathological process, when the proportion of affected cells reaches 80–90%, the secretion of insulin becomes residual, which leads to the clinical manifestation of the disease. The presence of C-peptide in blood serum indicates that the minimum level of insulin secretion is maintained. With complete destruction of ß-cells, the disease passes into the stage of absolute insulin deficiency.

The pathogenesis of the main clinical symptoms in IDD is determined by the extremely important physiological role of insulin in the regulation of all types of metabolism. With insulin deficiency, the intracellular oxidation of glucose is sharply reduced, its intravascular concentration (hyperglycemia) increases. Cellular deficiency of macroergs leads to the inclusion of compensatory mechanisms for the regulation of carbohydrate metabolism - activation of gluconeogenesis and glycogenolysis, an increase in the level of counterinsular hormones. The "vicious circle" of metabolic disorders is intensified by increased proteolysis and lipolysis, resulting in the accumulation of ketone bodies in the blood and metabolic acidosis. Blood hyperosmolarity leads to intracellular dehydration, when the "renal threshold" of glucose (10 mmol/l) is exceeded, it is filtered into the urine. Glycosuria further increases fluid loss from the vascular bed and can lead to hypovolemic shock. Dehydration, accumulation of ketone bodies, intermediate products of glucose metabolism (lactate) lead to pronounced acidotic changes in homeostasis, which are compensated for a certain time by renal and respiratory mechanisms. When they are ineffective, diabetic ketoacidosis develops, which is accompanied by multiple organ failure, loss of consciousness (coma) and, if timely treatment is not provided, the patient's death. Chronic complications of IDD are mainly associated with damage to the vascular bed (angiopathy) at its various levels. Diabetic angiopathies develop as a consequence of chronic hyperglycemia with unsatisfactory control of IDD and have general morphological signs: aneurysmal changes in capillaries, thickening of the wall of arterioles, capillaries and venules due to the accumulation of glycoproteins and neutral mucopolysaccharides in the basal membrane, proliferation of the endothelium and its desquamation in the lumen of vessels, which leads to to their obliteration.

## 3. Classification of diabetes mellitus in children

The classification of diabetes, adopted by the WHO in 1999, distinguishes the following types of disease (with abbreviations): 1) type I diabetes (autoimmune or idiomatic; 2) type II diabetes; 3) gestational diabetes mellitus; 4) other specific types: a) genetic defects of b-cell function; b) genetic defects in the action of insulin; c) diseases of the exocrine part of the pancreas (pancreatitis, trauma / pancreatectomy, neoplasia, cystic fibrosis, hemochromatosis, fibrocalculous pancreatopathy); d) endocrinopathy (acromegaly, Cushing's syndrome, glucagonoma, pheochromocytoma, thyrotoxicosis, somatostatinoma, aldosteroma); e) diabetes induced by drugs and chemicals; f) diabetes due to infectious diseases; g) unusual forms of immunogenic diabetes; c) other genetic syndromes associated with diabetes (Down, Klinefelter, Turner, Tungsten, Friedreich's

ataxia, Huntington's chorea, Lawrence-Moon-Biddle syndrome, Prader-Willi syndrome).

Classification of diabetes according to the stages of the process: potential diabetes (prediabetes), latent (hidden) and manifest (overt). Persons with prediabetes (risk group) include: monozygotic twins (if one of them has diabetes); children whose parents or close relatives have diabetes; children born weighing more than 4.5 kg; children with obesity and other endocrinopathies. Latent diabetes is diagnosed in the presence of "small symptoms" (recurrent pyoderma, periodontitis, inflammatory lesions of the genitals) in the absence of a detailed clinical picture of the disease. Confirmation of this condition is the altered nature of the glycemic curve when performing a standard glucose tolerance test.

According to the nature of the course of diabetes there are forms: mild, moderate and severe. They also describe the phase of metabolic disorders: compensated, subcompensated and decompensated diabetes (with and without ketosis).

There are levels of glycemic control for patients diagnosed with diabetes: ideal, optimal, suboptimal, and glycemic control with a high risk to life. When formulating a complete clinical diagnosis, the presence of diabetes complications (acute and chronic) must be indicated.

## 4. Clinical features of diabetes mellitus in children.

The onset of DM can be "masked" by a number of non-specific symptom complexes. Neuropathic syndrome is manifested by rapid fatigue, general malaise, weakness, headache, dizziness, memory impairment and deterioration of learning the curriculum (for schoolchildren). Manifestations of the skin syndrome are recurrent furunculosis and pyoderma, persistent atopic dermatitis in young children (eczema), skin itching. In addition, the mucous membranes of the oral cavity (stomatitis, gingivitis, cheilitis) and external genitalia (vulvitis, vaginitis in girls, balanoposthitis in boys, urethritis) may be affected. Skin and mucous membrane damage without any reason is characteristic - with satisfactory compliance with hygienic standards of care, in the absence of sexual contact in school-aged children. Ophthalmic syndrome can be manifested by deterioration of visual acuity, sudden appearance of myopia or hypermetropia, formation of cataracts. Abdominal syndrome - non-localized abdominal pain, vomiting, various manifestations of dyspepsia. Children often complain of pain in the muscles of the limbs, cramps in the lower legs, and a decrease in muscle strength.

The advanced clinical manifestation of IDD is accompanied by the appearance of such classic symptoms as polyuria and polydipsia (thirst). An increase in daily diuresis can also be due to the appearance of involuntary urination during day or night sleep (enuresis). A child can secrete up to 3-4 liters of urine per day and drink equivalent volumes of liquid. Another symptom of the diabetic "triad", characteristic of adult patients - polyphagia (increased appetite) - is observed less often in children, sometimes for a certain time before the manifestation of the disease. A decrease in appetite, which

indicates the development of diabetic ketosis, is more characteristic of IDD. One of the important clinical features of diabetes in children is a rapid loss of body weight (up to 5–10 kg) in a short time interval (1–2 months). Such weight loss is explained by the catabolic direction of metabolism under conditions of insulin deficiency.

At an early age, IZD is manifested by the cessation of weight gain or loss of body weight, increased appetite, thirst, persistent manifestations of "diaper rash" or atopic dermatitis, and general anxiety. Dryness of the skin, decrease in turgor of soft tissues are objectively determined. Before the period of widespread use of diapers, the symptom of "starchy diapers" after drying urine was described in the literature, which now has a more "historical" character.

**5. Acute and chronic complications of diabetes.**

The general clinical features of IDD in children, in contrast to adults, are: a rapid rapid manifestation (often the onset of the disease is manifested by diabetic ketosis - an increase in the level of ketone bodies in the blood serum, or coma), a labile course (a change in periods of hyper- and hypoglycemia, which changes the need for insulin during the day and complicates the individual selection of its dose). In some cases, at the beginning of the disease, manifestations of early hypoglycemic syndrome are possible - an imperative need for sweet food, sudden weakness, sweating, tremors of the limbs, dizziness. This condition is a consequence of inadequately large secretion of "residual" insulin in hyperglycemia caused by irrational nutrition. In case of inadequate therapy of IDD, the progressive development of late complications caused by macro- and microangiopathies is possible.

Manifestations of diabetic ketosis and ketoacidosis (DKA) are life-threatening and require prompt diagnosis and emergency care. There are three stages of DKA (synonyms – ketoacidotic, hyperglycemic, diabetic coma). In the 1st stage, against the background of dehydration symptoms (dryness and decreased elasticity of the skin, turgor of soft tissues), the accumulation of ketone bodies (ketosis) provokes nausea, abdominal pain, and loose stools (manifestations of toxic gastroenteritis). Since the manifestations of abdominal syndrome can mask the clinic of "acute abdomen", they require consultation of a surgeon. Diabetic rubeosis (reddening of the skin on the cheeks, eyebrows, chin) is detected, the tongue is dry, coated with a white coating. In exhaled air, it is possible to detect the characteristic smell of acetone (rotten fruit). At this stage, the level of consciousness is disturbed, the patient is inhibited, muffled, sometimes somnolent. To provide emergency care, it should be taken into account that the degree of dehydration at this stage, as a rule, does not exceed 5% of body weight.

With the progression of metabolic disorders, depletion of the main is possible (alkaline) blood reserve. The mechanism of compensation for acidotic shifts in metabolism is increased excretion of hydrogen ions with urine and carbon dioxide with exhaled air. A clinical sign of the beginning of the 2nd stage of DKA is a noisy deepened toxic Kussmaul breathing (bradypnea). The degree of unconsciousness reaches sopor (the patient can be awakened only under the influence of strong stimuli). Signs of abdominal syndrome intensify, muscle defense, symptoms of peritoneal irritation, vomiting

(pseudoperitonitis) are repeated. Circulatory disorders increase - blood pressure decreases, compensatory tachycardia, acrocyanosis appears. As a result of dehydration, a decrease in stroke and cardiac output, filtration pressure in the kidneys decreases, which leads to signs of kidney failure. The amount of urine decreases and polyuria, which occurred before the decompensation of diabetes, changes to oliguria. The degree of dehydration in the 2nd stage of DKA exceeds 5% of body weight.

The terminal 3rd stage of DKA, or actually coma, is characterized by complete loss of consciousness, lack of response to any stimuli, suppression of unconditioned and tendon reflexes, lack of reaction of the pupils to light, muscle hypotonia. Vomiting may stop, but hemodynamic disorders worsen. Diuresis decreases to the degree of anuria, heart rhythm disturbances are possible as a result of electrolyte disorders (primarily, hyperkalemia, which complicates acute renal failure). Against the background of cerebral edema, multiple organ failure, and the addition of DIC-syndrome, if emergency intensive care is not provided, a quick fatal outcome is possible.

With IDD in children, it is also possible to develop other clinical variants of coma. Hyperosmolar (non-ketoacidotic) coma develops more often in the presence of additional fluid loss (except for polyuria caused by diabetes itself) - intestinal infections, burns, bleeding. The pathogenesis of coma is due to significant hyperglycemia, hypernatremia, which lead to pronounced cellular dehydration, a violation of the water-electrolyte balance in brain cells. This variant of coma is characterized by a slower development than DKA. Sharp dehydration in the absence of acidosis and ketosis is characteristic (pronounced dryness of the skin and mucous membranes, the tongue is covered with a brown coating, a decrease in blood pressure, tachycardia, a decrease in the tone of the eyeballs and muscles, progressive weakness). With hyperosmolar coma, an increase in body temperature is possible, various neurological symptoms are observed - a feeling of twitching in the muscles of the limbs, aphasia, convulsions, paresis, nystagmus, hallucinations. Changes in the rheological properties of blood lead to blood vessel thrombosis and thromboembolic complications.

Hyperlactacidemic coma (lactic acidosis) develops in patients with diabetes mellitus who have additional conditions contributing to hypoxia - severe anemia, heart defects, pneumonia. The development of this variant of coma is rapid, the features are a pronounced pain syndrome due to the accumulation of lactate (muscle pain, pain in the projection of the anterior abdominal wall, transverse area), dyspeptic disorders (anorexia, nausea, vomiting), acidotic breathing. Unlike DKA, smell there is no acetone in the air. Disturbances of consciousness can begin with excitement, which gradually turns into somnolence, sopor and coma.

Along with conditions accompanied by impaired consciousness and associated with hyperglycemia, the development of a hypoglycemic state (coma) is often observed in the course of DM. Hypoglycemia is more specific for patients who will already receive insulin for the treatment of IDD, that is, for patients with an already established diagnosis. The reasons for its development can be physical overload and a long break in eating, an inadequately high dose of insulin, increased sensitivity to insulin. Most often,

hypoglycemia is a consequence of dietary disorders when the usual doses of insulin are administered correctly. Disruption of glucose supply to the brain is accompanied by a lack of its functions, including higher nervous activity. The clinic of hypoglycemia consists of symptoms of neuroglycopenia (hunger, headache, reduced work capacity, inappropriate behavior, euphoria, aggression, negativism, visual disturbances, convulsions, trismus of the masticatory muscles, impaired consciousness) and symptoms due to compensatory hypercatecholaminemia (tremor, pallor, sweating, tachycardia, increased blood pressure, excitement). Consciousness in hypoglycemia is lost quickly (in contrast to DKA, in which the patient's condition worsens gradually).

In addition to acute complications of diabetes (various types of coma), chronic or late complications play an important role in the course and prognosis of the disease. It is important that long-term careful control of diabetes significantly reduces the risk of development and progression of diabetic complications.Diabetic retinopathy – microangiopathy of retinal vessels, leads to complete loss of vision in the terminal stage of the disease. Diabetic retinopathy develops more often in teenage than younger children. In the initial stage of the development of this complication (nonproliferative diabetic retinopathy), the patient has no complaints, but microaneurysms on the retina, edema in the macular zone, and exudative foci are revealed during ophthalmoscopy. In the second stage, visual acuity decreases, scotomas appear, venous vessel anomalies, a large amount of exudates on the fundus, and retinal hemorrhages are identified. At the 3rd stage (proliferative diabetic retinopathy), a sharp decrease in visual acuity up to complete blindness, hemorrhages in the vitreous body, neovascularization of the optic nerve disc, and the formation of fibrous tissue in the areas of preretinal hemorrhages are determined on the retina. This stage is complicated by retinal detachment.

Diabetic nephropathy (Kimelstiel-Wilson syndrome) is a specific lesion of the kidney vessels in diabetes, accompanied by the formation of nodular or diffuse glomerulosclerosis, the terminal stage of which is characterized by the development of chronic renal failure. The risk of developing diabetic nephropathy is higher in patients with the onset of the disease at the age of puberty compared to patients in whom the debut of the disease fell before the age of 10 years. This is primarily a chronic process, which is initially manifested by nephron hypertrophy and hyperfiltration. The clinically pronounced stage of diabetic nephropathy is preceded by years of transient or permanent microalbuminuria, which is the earliest marker of this complication.

Diabetic neuropathy is more often manifested in the form of distal symmetrical sensory-motor polyneuropathy of the lower extremities. The main symptoms are pain, paresthesia, decreased tendon reflexes, impaired tactile, temperature, and pain sensitivity.

Diabetic keuropathy (diabetic hand syndrome) is defined by limited joint mobility, characterized by painless contractures that develop mainly in the hands. Diabetic cheiropathy can serve as an early harbinger of IDD complications due to chronic hyperglycemia.

Diabetic hepatosis is a fatty hepatosis (fatty infiltration of the liver), which develops

during long-term decompensation of diabetes, as a result of the depletion of glycogen reserves and the excessive supply of free fatty acids, neutral fat to hepatocytes. At the same time, an increase in the size of the liver is determined, sometimes - pain during palpation due to stretching of the capsule and violation of the outflow of bile.

The consequence of chronic long-term decompensation of diabetes is the development of Moriac syndrome. Chronic insulin deficiency with moderate hyperglycemia contributes to an increase in the level of counterinsular hormones (mainly glucocorticoids), which causes growth retardation, obesity with excessive deposition of fat in the chest, abdomen, thighs, and face (Cushing type). Fatty dystrophy of the liver is also determined, and in the pubertal period – delay in sexual development.

**6. Laboratory diagnostics**. The diagnosis of diabetes is based on the detection of clinical signs and is confirmed by the data of laboratory tests. The main biochemical marker of diabetes is an increase in the fasting blood glucose level.Normally, the glucose content in capillary blood is 3.3–5.5 mmol/l. With fasting blood glucose up to 6.1 mmol/l, a standard oral glucose tolerance test is performed (Table 10), for which the child is given per os glucose 1.75 g/kg, but not more than 75 g. When receiving twice the level fasting glycemia in capillary blood > 6.1 mmol/l or in venous blood > 7.0 mmol/l, or selectively ≥ 11.1 mmol/l, the diagnosis of diabetes is not in doubt and the test is not performed.

**TABLE 1 -- Diagnostic Criteria for Impaired Glucose Tolerance and Diabetes Mellitus**

| IMPAIRED GLUCOSE TOLERANCE (IGT) | DIABETES MELLITUS (DM) |
|---|---|
| Fasting glucose 110–125 mg/dL (6.1–7.0 mmol/L) | Symptoms[*] of DM plus random plasma glucose ≥200 mg/dL (11.1 mmol/L) |
| | *or* |
| 2-hr plasma glucose during the OGTT but ≤140 mg/dL | Fasting plasma glucose ≥126 mg/dL (7.0 mmol/L) |
| <200 mg/dL (11.1 mmol/L) | *or* |
| | 2-hr plasma glucose during the OGTT ≥200 mg/dL |

Manifestations of diabetes are glucosuria (detected by quantitative or qualitative methods), an increase in the specific gravity of urine (above 1030), hypersthenuria and nicturia in the Zimnytskyi test. When ketosis develops, ketone bodies (acetonuria) are determined in the urine analysis.

In order to monitor the course of IDD during insulin therapy, as well as to retrospectively assess the state of compensation of the disease, the level of glycated (glycosylated) hemoglobin (HbA1c), that is, its fraction to which a glucose molecule is

attached without the participation of enzymes, is determined. An increase in the level of glycated hemoglobin of more than 7% indicates an increase in the average level of glycemia for the previous 3-4 months and helps to confirm the presence of carbohydrate metabolism disorders of the diabetic type.

Additional diagnostic markers of IDD are a decrease or absence of C-peptide in the serum, an increased level of fructosamine, the presence of antibodies to antigens of ß-cells and to insulin, radioimmunological determination of the concentration of insulin in the blood.

If there are signs of DKA, it is mandatory to monitor the electrolyte status of the blood (potassium, sodium, chlorine), ABB (pH, blood gases, bicarbonate), kidney function (urea, blood creatinine), osmolarity, hemostasis system (coagulogram).

**7. Differential diagnosis**. Difficulties in the diagnosis of IDD may arise if the child has other conditions accompanied by hyperglycemia. Most often, this happens with infectious lesions of the central nervous system (encephalitis), brain injuries, significant dehydration with acute gastroenteritis, poisoning with salicylates (aspirin).The symptom of polyuria requires differential diagnosis with diabetes insipidus. In this disease, thirst and loss of appetite are also determined, but, unlike diabetes, thirst in diabetes insipidus is strong and exhausting, and polyuria reaches 8–10 liters. With significant dehydration, hyperthermia and neurological disorders are observed. The level of glucose in the blood is normal, there is no glucosuria, the specific gravity of urine is extremely low (hypoisosthenuria in the test according to Zimnytskyi).

The presence of glucosuria without hyperglycemia is possible in tubulopathies, Debret-de-Thony-Fanconi disease, and benign renal glucosuria.

Vomiting in DKA needs to be differentiated from cyclic vomiting syndrome (acetonemic syndrome).

**8. Treatment of diabetes**. The directions of therapy of IDD in children are the correction of metabolic disorders, and, first of all, the elimination of hyperglycemia and glycosuria. Compensation of the disease prevents the occurrence of late vascular complications, and constant glycemic control reduces the risk of developing acute decompensation. Upon reaching normal or close to normal levels of glucose in the blood, its lipid spectrum and the content of counterinsular hormones gradually normalize. Compensated IDD leads to satisfactory physical development of the child, normal ability to perform academic or other workloads, full-fledged social adaptation. The motto that the patient and his doctor should follow is "Diabetes is not a disease, but a changed way of life." Basic in the treatment of IDD is medication, but the issues of physical activity and diet are also extremely important. Dosed physical activity can be performed at a blood glucose level of no higher than 12–14 mmol/l, it is a mandatory therapeutic factor, helping to reduce the level of glucose in the blood and even reducing the need for insulin (due to the activation of insulin receptors). Physical activity may include morning gymnastics, dosed walking, physical therapy, and some sports (sports games, athletics, tennis). It is recommended to exercise 1-2 hours after eating.

Diet therapy is an extremely important component of disease therapy. Food should be

varied, adapted to age, suitable for physical activity and the mode of insulin administration. Preference is given to cereals (buckwheat, oat, pearl barley), rye bread, vegetables and fruits, salt and sugar are limited. Foods with easily digestible carbohydrates (honey, grapes, cookies, banana) should be limited in the diet (or excluded, in case of unsatisfactory self-control). The consumption of fats is not prohibited at an early age, but it is not desirable for older children and adolescents. Preference is given to products that contain polyunsaturated fatty acids (unrefined vegetable oils). Proteins should be complete (animal proteins make up 2/3 of the daily norm). Foods rich in methionine (cottage cheese, soy, cod) are widely used, and foods containing cholesterol (eggs, liver, caviar) are limited. The optimal frequency of meals during the day includes 3 main and 3 additional (light) meals.The daily calorie content of food for a child is calculated according to the formula: 1000 kcal + 100 kcal for each year of his life. Of this amount, the share of carbohydrates is 50–55%, fats – 30%, proteins – 15–20%. After calculating the number of calories accounted for by carbohydrates, determine the number of bread units) for the possibility of exchanging products (12 g of carbohydrates = 1 bread unit), which allows you to replace products with an equivalent amount of carbohydrates. This calculation is based on the physiological release of 4 kcal when assimilating 1 g of carbohydrates. The recommended distribution of daily calories between meals is as follows: breakfast - 25%, lunch - 30%, dinner - 25%, second breakfast - 10%, afternoon snack - 5%, second dinner - 5%.

Based on the etiopathogenesis of IDD, medical treatment with insulin drugs is an alternative method in pediatric endocrinology. For the treatment of children and adolescents, only human genetically engineered insulins or insulin analogs are recommended for use. There are drugs of ultra-short, short-acting, medium-duration, long-acting and mixtures of insulins of different duration of action in different ratios (Table 11).

Immediately after the diagnosis of DM, the child is prescribed short-acting insulin subcutaneously before the main meals (4-6 times a day), sometimes a combination of fast-acting and long-acting insulin twice a day is possible. After a few days, they switch to the combined administration of long-acting (before breakfast and at night) and short-acting (before the main meals) insulins (analogues). The need for insulin during decompensation may exceed 1.5–2 units/kg of body weight day. After achieving compensation of carbohydrate metabolism, the dose of insulin is usually reduced. The recommended daily insulin requirements are as follows: at the onset of diabetes – 0.5–0.6 units/kg, in the remission period (minimum endogenous insulin secretion is maintained, the “honeymoon” period) – < 0.5 units/kg, with long-term diabetes – 0.7–0.8 units/kg, during decompensation (DKA) – 1.0–1.5 units/kg, during prepuberty – 0.6–1.0 units/kg, during puberty – 1, 0–2.0 units/kg.

Table 11. Types of insulin preparations used to treat children with diabetes

| *Insulin* | Onset of action | Peak of action | Maximal duration of action |
|---|---|---|---|
| Short action (Actrapid NM, Humulin Regular, Insuman Rapid) | 30 min | 1–3 h | 6–8 h |
| Rapid-acting insulin analogues (NovoRapid, Epidra, Humalog) | 10–20 min | 1–3 h | 3–5 h |
| Long-acting (Protafan NM, Humulin NPH, Insuman Basal) | 1–2 h | 4–12 h | 18–24 h |
| Pre-mixed 30/70 (Mixtard 30/70, Humulin M3) | 0,5–1 h | 5–9 h | 18–24 h |
| Pre-mixed 50/50 | 0,5–1 h | 1–3 h | 18–24 h |
| Pre-mixed insulin analog (NovoMix 30) | 10–20 min | 1–3 h<br>4–12 h | 18–24 h |
| Analogues of long-acting insulin(Lantus | 1–2 h | Peak-free | 11-24 h |
| Levemir) | | | 16-24 h |

Individual characteristics of the course of the disease and the age of the patient determine different regimens (multiplicity of administration) of insulin therapy (Table 12).

| Number of injections. | Distribution of the daily dose of insulin |
|---|---|
| Two injections per day | ▪ 2/3 of the daily dose - before breakfast<br>▪ 1/3 dose – before dinner:<br>▪ - 2/3 of the daily dose – long-acting insulin<br>- 1/3 of the daily dose – short-acting insulin |
| Three injections per day | ▪ 40–50 % of the daily dose – before breakfast:<br>- 2/3 of the morning dose – long-acting insulin<br>- 1/3 – short-acting insulin<br>▪10–15% of the daily dose – before dinner (short-acting insulin)<br>▪ 40% of the dose – before going to bed (long-acting insulin) |
| Multiple administration | ▪ 30–40% of the daily dose – before going to bed (long-acting insulin)<br>▪ 60–70% of the dose – before the main meals (short-acting insulin) |

One of the frequent complications of insulin therapy is lipodystrophy (changes in the skin and subcutaneous fat in the form of areas of atrophy or hypertrophy in the places where insulin is injected). For its prevention, it is necessary to periodically change the injection sites of the drug. With a chronic overdose of insulin, the development of

Somoji syndrome is possible, which is manifested by increased appetite, growth acceleration, obesity, hepatomegaly, a tendency to ketoacidosis and hypoglycemia.

Control of the treatment of diabetes mellitus is carried out with the help of self-monitoring of the level of glucose in the blood, the presence of glucose in the urine, and the determination of the level of glycosylated hemoglobin (HbA1c) every 3 months.

Treatment of DKA is carried out, as a rule, in intensive care units. Its directions are rehydration, elimination of insulin deficiency, restoration of normal extra- and intracellular composition of electrolytes, restoration of acid-base balance (ABB), prevention of CVD syndrome and infectious complications, brain edema.

A very rapid decrease in intravascular hyperosmolarity can cause brain edema. Therefore, rehydration should be carried out slowly - within 24-48 hours, if necessary - longer. Solutions are introduced in a heated state to 37º. Rehydration is carried out with a 0.9% sodium chloride solution (with hyperosmolarity - with a 0.45% sodium chloride solution). After lowering glycemia to 12–15 mmol/l – replacement with solutions containing glucose (0.9% or 0.45% sodium chloride solutions with 5% glucose solution). The amount of required fluid is calculated as the sum of the fluid deficit (ml) and the maintenance daily amount of fluid (ml).Fluid deficit (ml) is equal to the degree of dehydration (%) multiplied by body weight (kg). The degree of dehydration can be roughly determined clinically: 3% - clinically almost not manifested; 5% – dry mucous membranes, reduced turgor; 10% – sunken eyes, poor filling of capillaries, their filling time > 3 seconds, cold extremities; 20% – shock, weak pulse on the periphery or its absence. Maintaining fluid needs are presented in table 13. In the first hour, 20 ml/kg of solutions are bolus administered, in the second hour - 10 ml/kg, during the third hour and in the future - 5 ml/kg.

Table 13. Maintenance daily amount of liquid (ml)

| Age (years) | Body mass (кg) | Fluid volume (ml/kg/24 hours): |
|---|---|---|
| < 1 | 3–9 | 80 |
| 1–5 | 10–19 | 70 |
| 6–9 | 20–29 | 60 |
| 10–14 | 30–50 | 50 |
| > 15 | > 50 | 35 |

Insulin therapy is started only after successful withdrawal from shock and the beginning of rehydration. During the first 60-90 minutes from the start of rehydration, blood glucose can drop significantly even without insulin therapy. Insulin (only short-acting) is administered in the mode of small doses, continuously intravenous drip; the initial dose is 0.1 units/kg/hour. The rate of reduction of glycemia should be slow - no faster than 4-5 mmol/l/h. During the first day of treatment, glycemia should not be lowered below 13 mmol/l, as a rapid decrease in glycemia can cause the development of cerebral

edema. Next, they switch to subcutaneous insulin administration only if blood glucose is reduced to < 14 mmol/l and with normal KOS indicators.

The primary cause of metabolic acidosis is insulin deficiency. Therefore, ABB is restored with adequate insulin therapy and rehydration. The rationale for sodium bicarbonate administration is severe ketoacidosis (pH < 7.0). If, an hour after rehydration and insulin therapy, shock phenomena persist, pH remains < 7.0, sodium bicarbonate is administered in a dose of 1–2 mmol/kg. Additional administration of potassium chloride solution is mandatory. When pH > 7.0 is reached, sodium bicarbonate administration is stopped.

**9. Prevention**. Primary prevention of IDD includes selection of a risk group (children with IDD, carriers of "diabetic" HLA haplotypes, children with obesity) and a thorough examination of these children (standard glucose tolerance test, determination of antibodies to pancreatic tissue and insulin) along with dietary recommendations about a rational diet with a restriction of easily digestible carbohydrates.Secondary prevention of IDD is aimed at reducing acute and chronic complications in patients with an established diagnosis of IDD, which is achieved by regular metabolic monitoring and adequate therapy. It is advisable to involve sick children to study in "Diabetes Self-Control Schools", which are organized at endocrine dispensaries or specialized endocrinological departments of hospitals. The main directions of counseling a child with diabetes are teaching him the correct technique of administering insulin drugs, calculating the daily ration depending on the number of bread units allowed by age, observing proper care of the skin, mucous membranes, and nails.

Forecast. Complete recovery from IDD is currently impossible. A promising method of treatment that can significantly improve the prognosis of such patients is the use of gene therapy with the replacement of damaged pancreatic tissue. With long-term stable compensation, the prognosis for life and working capacity is favorable. The quality of life of patients with diabetes mellitus and adherence to treatment can significantly improve with the appearance on the pharmaceutical market of non-injectable insulin preparations (in the form of aerosol inhalers), which are undergoing clinical trials at the beginning of the 21st century.

**Materials for activating applicants of higher education during the lecture (questions, tasks, problem situations, etc.). (if necessary).**

**General material and general methodological support of the lecture: computer equipment, multimedia projector, multimedia presentation.**

**Questions for self-control:**

1) Clinical and diagnostic criteria of diabetes in children.
2) Peculiarities of the course of the disease in childhood.
3) Basic principles of diabetes treatment.
4) Peculiarities of diet therapy for diabetes.
5) Algorithms for providing emergency care in comatose states.
6) Prevention of chronic complications of diabetes in children.

**List of used sources:**

**Main:**

1. Nelson Textbook of Pediatrics, 2-Volume Set, 22nd Edition, 2024. Robert M. Kliegman, Joseph W. St. Geme III, Nathan J. Blum, et al.

2. Nelson Textbook of Pediatrics / R. M. Kliegman [et al.]; ed. R. E. Behrman. - 21th ed. - Edinburgh [etc.]: Elsevier, 2020. - Vol. 1. – LXXV.Nelson textbook of pediatrics, 2 volume set. Edition: 21st, 2019. PDF format. http://pediacalls.com/e-books/nelson-textbook-of-pediatrics-21st-edition/
3. Nelson Textbook of Pediatrics. Expert Consult Premium Edition. Enhanced Online Features and Print 19th Edition ISBN-13: 978-1437707557 https://www.amazon.com/s?i=stripbooks&rh=p_27%3ARobert+M.+Kliegman+MD&s=relevancerank&text=Robert+M.+Kliegman+MD&ref=dp_byline_sr_book_1

**Additional:**

-Diabetes Increases in Children and Teens. Health Capsule, June 2017 https://newsinhealth.nih.gov/2017/06/diabetes-increases-children-teens

-Managing Diabetes. 4 Steps to Manage Your Diabetes for Life https://www.niddk.nih.gov/health-information/diabetes/overview/managing-diabetes/4-steps

-Diabetes Overview. What is Diabetes?Monogenic Diabetes (Neonatal Diabetes Mellitus&MODY)https://www.niddk.nih.gov/healthinformation/diabetes/overview/what-is-diabetes/monogenic-neonatal-mellitus-mody

- Emergency medical care: new clinical protocol (order of the moh of Ukraine of 05.06.2019, №1269).

-Diabetes (type 1 and type 2) in children and young people: diagnosis and management: NICE guidance.-2022. www.nice.org.uk/guidance/ng18.

-Children and Adolescents: Standards of Medical Care in Diabetes. *Diabetes Care* 2021;44(Supplement_1):S180–S199 -2021. https://doi.org/10.2337/dc21-S013

**Electronic information resources:**

1. http://moz.gov.ua– Міністерство охорони здоров'я України
2. www.ama-assn.org – Американська медична асоціація / American Medical Association
3. www.oapn.od.ua- ГО "Одеська Асоціація лікарів-педіатрів та неонатологів"
4. www.who.int – Всесвітня організація охорони здоров'я
5. www.dec.gov.ua/mtd/home/ - Державний експертний центр МОЗ України
6. http://bma.org.uk– Британська медична асоціація
7. www.gmc-uk.org- *General Medical Council* (*GMC*)
8. www.bundesaerztekammer.de – Німецька медична асоціація
9. https://www.who.int/workforcealliance/members_partners/member_list/ipa/en/ - Міжнародна асоціація педіатрів / International Pediatric Association (IPA).
10. https://ginasthma.org/wp-content/uploads/2024/05/GINA-2024-Strategy-Report-24_05_22_WMS.pdf GINA Global Initiative For Asthma. 2024
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13. https://nam.edu/ The National Academy of Medicine (NAM)
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