

Ministry of Health of Ukraine
Bogomolets National Medical University

METHODOLOGICAL RECOMMENDATIONS

for practical classes for students

Academic discipline: MC25. Propaedeutics of pediatrics including nursing practice, basic medical skills in the pediatric department

Area of knowledge: 22 "Healthcare"

Specialty: 222 "Medicine"

Department of Pediatrics № 2

Approved at the meeting of the department dated August 27, 2026, protocol №1

Considered and approved: Central Medical Committee on Pediatric Disciplines
dated August 28, 2026 protocol №1

**Topic of the Lesson: Features of the blood system in children of different age groups.
Methods of clinical and laboratory examination of children with blood system lesions.
Clinical and hematological semiotics of the main syndromes and diseases of the blood system in children.**

1. Goal: Formation of professional competencies to achieve program learning outcomes regarding the anatomical and physiological features, methodology of physical examination, and semiotics of blood system diseases in children, namely:

Acquisition of knowledge regarding:

- Stages of intrauterine hematopoiesis.
- Features of peripheral blood in neonates.
- Clinical and hematological semiotics of the main syndromes (anemic, hemolytic, hemorrhagic, etc.) and diseases of the blood system in children.

Acquisition of skills regarding:

- Evaluation of laboratory test results of the blood system in children of different ages.
- History taking and identification of data indicating changes in the child's blood system.
- Conducting an objective physical examination of the blood system, considering age-related features.

2. Competencies

- Developing a diagnostic algorithm for children with blood system pathology.
- Interpretation of laboratory test results in children with blood system pathology.

Equipment: Textbook, computer, medical mannequin, tongue depressor.

3. Plan and Organizational Structure of the Lesson

Stage Name	Stage Description	Levels of Mastery	Time (min)
Preparatory Stage	Organizational measures. Setting educational goals, motivating students	*	10
Main Stage	Test control on the lesson topic, checking and announcing results.- Theoretical questioning.Demonstration of practical skills, clarification of the most important points regarding the evaluation of general and biochemical blood test results in children, determination of the main syndromes (anemic, hemolytic, hemorrhagic, etc.). Students' work on acquiring skills in the clinical examination of children with hematopoietic system pathology. Solving problems related to the lesson topic.	**.	20
		*, **, ***	55
		****	20

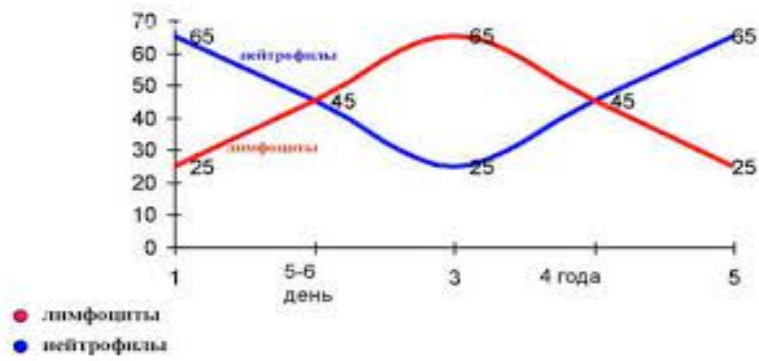
Final Stage	Analysis and evaluation of students' work results. Announcing the topic of the next lesson, providing a reference guide for independent literature study	*	10
Total		2.5 academic hours	115

Levels of mastery: * Introductory, ** Reproductive, *** Reconstructive, **** Creative.

4. Content of the Educational Material

4.1. List of main terms, parameters, and characteristics to be mastered by the student:

Term	Definition
Medullary hematopoiesis	Bone marrow hematopoiesis – begins from the 4th month of intrauterine development and becomes the primary mode of hematopoiesis by the end of fetal development and throughout life
Hematocrit (Ht)	The ratio of the volume of formed elements to the volume of blood plasma. In adults, it is 40–45%. At 2.5 months of intrauterine development, it is 31–36%; in an 8-month fetus, 40–45%. On the 1st day after birth, hematocrit is higher than in adults, averaging 54–60%. This high hematocrit is due to a high concentration of erythrocytes and a large mean volume of individual erythrocytes.
HbF / HbA	Fetal hemoglobin / Adult hemoglobin
Features of hematopoiesis in children of different ages	1. In neonates, hematopoiesis occurs in the red bone marrow of all bones. After 4 years of age, red bone marrow gradually converts to yellow bone marrow. By 12–15 years, hematopoiesis is retained only in the bone marrow of flat bones, ribs, vertebral bodies, and proximal ends of the humerus, forearm, and femur. 2. In early childhood, the hematopoietic system exhibits functional lability. Under the influence of adverse factors, a reversion to the embryonic type of hematopoiesis is possible, with the appearance of myeloid and lymphoid metaplasia in the bone marrow. 3. Blood volume relative to body weight is higher in children than in adults. In neonates, it averages 15%; in 1-year-olds, 11%; in adults, 7%. 4. Blood viscosity in neonates is higher than in adults but reaches adult levels within the first week of life 5. Erythrocyte sedimentation rate (ESR) in neonates is low (1–2 mm/h), increasing with age (infants: 2–4 mm/h; older children: 4–12 mm/h). Normal ESR should not exceed 15 mm/h 6. Hematocrit in neonates is higher (55%) than in adults (40–45%). In infants, it is 35%, reaching adult levels by 15 years of age 7. Peripheral blood in neonates is characterized by an elevated number of erythrocytes and hemoglobin. In the first two days of life, erythrocyte count is $5-7 \times 10^{12}/L$, and hemoglobin reaches 180–240 g/L. From day 2 to 6 months, hemoglobin levels decrease (120–125 g/L), then gradually increase, averaging 130–140 g/L by 15 years. The lower limit of this indicator for children under 5 years is 110 g/L, and for those over 5 years, 120 g/L (WHO data).

	8. In the first months of life, HbF predominates (up to 80%), with HbA at 20–30%. Neonatal erythrocytes exhibit hyperchromia, poikilocytosis, anisocytosis, and the presence of normocytes and erythroblasts. Reticulocyte count in neonates is increased (up to 40‰ or 4%), decreasing to 20–25‰ (2–2.5%) by 3 months, and to 10‰ (1%) after 1 year of age. 9. At birth, children exhibit physiological leukocytosis ($10\text{--}30 \times 10^9/\text{L}$), which subsequently decreases to $8\text{--}9 \times 10^9/\text{L}$ by 1 year of age. 10. Platelet count in children is independent of age and sex, equaling $150\text{--}400 \times 10^9/\text{L}$.																									
Neutrophil-Lymphocyte Crossovers	In neonates, blood contains 60–65% neutrophils with a shift to myelocytes. Starting from day 2 of life, the neutrophil count decreases while the lymphocyte count increases. On days 4–6, the **first crossover** occurs, when neutrophil and lymphocyte counts become equal. Subsequently, the lymphocyte count increases to 60–65%. Later, a gradual decrease in lymphocytes and an increase in neutrophils is observed. At 5–6 years of age, the *second crossover* occurs, after which the leukocyte formula gradually approaches that of adults. 																									
Normal hemoglobin levels	<table><tr><td>6–59 mo</td><td>≥110</td><td>100–109</td><td>70–99</td><td><70</td></tr><tr><td>5–11 yr</td><td>≥115</td><td>110–114</td><td>80–109</td><td><80</td></tr><tr><td>12–14 yrs & non-pregnant women ≥15 yrs</td><td>≥120</td><td>110–119</td><td>80–109</td><td><80</td></tr><tr><td>Pregnant women</td><td>≥110</td><td>100–109</td><td>70–99</td><td><70</td></tr><tr><td>Men (≥15 yrs)</td><td>≥130</td><td>100–129</td><td>80–109</td><td><80</td></tr></table>	6–59 mo	≥110	100–109	70–99	<70	5–11 yr	≥115	110–114	80–109	<80	12–14 yrs & non-pregnant women ≥15 yrs	≥120	110–119	80–109	<80	Pregnant women	≥110	100–109	70–99	<70	Men (≥15 yrs)	≥130	100–129	80–109	<80
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Features of the myelogram in children	Bone marrow aspiration and evaluation of its quantitative and qualitative composition (myelogram) are crucial for diagnosing or excluding hematopoietic disorders and assessing treatment efficacy. The ratio of white to red blood cell elements (myeloerythroblastic coefficient) is established at a constant level (3:1) as early as infancy. The number of blast cells in normal conditions is no more than 5%. In the first 3 years of life, the myelogram shows a higher percentage of lymphocytes: 10–15% in infancy, 7–14% at 1–3 years, and 2–8% in children older than 3 years. There are no significant morpho-functional differences in the bone marrow picture between healthy children and adults																									

Features of hemostasis in children	Hypercoagulability of whole blood against a background of low levels of both anticoagulants (Antithrombin III, Proteins C and S) and procoagulants (prothrombin, proaccelerin, factors IX, X, XI). Hypercoagulability is driven by erythrocyte hemolysis and decreased Antithrombin III at this age. A characteristically low level of vitamin K-dependent factors (II, VII, IX, X), synthesized by hepatocytes, is most typical for neonates. Platelet adhesiveness is normal, but aggregation is reduced.
Methodology of examining the hematopoietic system in children: Complaints	Weakness, lethargy, decreased exercise tolerance, dyspnea, poor or distorted appetite, dry pale or yellowish skin, brittle nails, koilonychia. Possible decreased attention, nervousness, neuropathies, bleeding, bruising, enlarged lymph nodes, pallor of skin and mucous membranes, ossalgia, weight loss, pruritus. (i.e., signs of hemorrhagic, anemic, sideropenic, or proliferative syndromes.
History of Present Illness	Date of symptom onset, conditions of their emergence, dynamics of pathological symptoms, results of previous laboratory examinations.
Life History:	Prematurity, maternal anemia and toxicoses, multiple pregnancies, feeding methods, presence of immune conflict, intrauterine infections, past illnesses.
Examination:	Assessment of the child's general condition, skin and mucous membrane color, presence of hemorrhagic syndrome or tumors, hepatosplenomegaly, etc. Physical Examination: Assessment of lymph nodes, cardiovascular system, and abdominal organs.
Evaluation of Laboratory Results:	Hemogram, myelogram, lymphadenogram, coagulogram. If absent and indicated, a diagnostic plan must be prescribed to confirm or exclude hematological pathology.
Anemia:	A pathological clinical and laboratory symptom complex characterized by a decrease in hemoglobin content and/or erythrocytes per unit volume of blood below 2 standard deviations. In early childhood, iron deficiency anemia is the most common.
Mechanisms of Anemia Development:	Anemias associated with acute or chronic blood loss (posthemorrhagic). * Anemias due to impaired erythropoiesis (hypo- and aplastic, deficiency anemias, including iron deficiency, anemia of prematurity). * Anemias caused by increased erythrocyte destruction (hemolytic). * Erythrocyte indices, primarily MCV, help narrow and direct the diagnostic search
Deficiency Anemia:	A type of anemia caused by a deficiency of iron (sideropenic), protein, vitamins (B12, folic acid), or trace elements in the body, related to inadequate intake, malabsorption, or increased excretion.
Hypo- and Aplastic Anemias	Bone marrow failure, insufficiency of erythropoiesis.
Hemolytic Anemia:	Resulting from premature destruction of erythrocytes.

Erythrocyte Indices:	MCV (Mean Corpuscular Volume):** Average erythrocyte volume, measured in femtoliters (fL) or cubic micrometers ($1 \text{ fL} = 1 \mu\text{m}^3$) (Normal: 80–100 fL), or mean erythrocyte diameter (Normal: 7–8.5 μm). * Microcytic anemias: mean diameter < 7 μm, MCV < 80 fL. * Normocytic anemias: mean diameter 7–8 μm, MCV = 80–100 fL. * Macrocytic anemias: mean diameter > 9 μm, MCV > 100 fL. MCH (Mean Corpuscular Hemoglobin): Average hemoglobin content per erythrocyte (pg), characterizes the amount of hemoglobin in 1 erythrocyte, corresponds to the color index (Normal: 27–31 pg or 0.85–1.0). Changes in MCH underlie the classification of anemias into normochromic (MCH 27–31 pg), hypochromic (MCH < 27 pg), and hyperchromic (MCH > 31 pg). Decreased MCH is observed in anemias caused by impaired hemoglobin synthesis (iron deficiency anemia, porphyria); increased MCH is seen in macrocytic and especially megaloblastic anemias. MCHC (Mean Corpuscular Hemoglobin Concentration):Characterizes the "packing density" of hemoglobin in the erythrocyte, calculated as: $\text{MCHC} = (\text{Hemoglobin} \times 100) / \text{Hematocrit} (\%)$. Normal: 320–360 g/L. This indicator increases in hemolytic anemias (spherocytosis, ovalocytosis) and sometimes in hyperosmolar water-electrolyte imbalances; it is falsely elevated in hyperlipidemia. It decreases in iron deficiency anemia, thalassemia, sideroblastic anemia, and hypoosmolar water-electrolyte imbalances. RDW (Red Cell Distribution Width): Distribution of erythrocytes by volume, quantifying the degree of anisocytosis. Normal: 11.5–14.5%. Reticulocytes: Immature erythrocytes. Normal: 0.5–2% (absolute count: $50\text{--}150 \times 10^9/\text{L}$).
Other Laboratory Parameters:	Pathological Erythrocyte Forms: A healthy erythrocyte is a biconcave disc (discocyte), ensuring elasticity and optimal oxygen transport. Change in shape is poikilocytosis, change in size is anisocytosis, and change in color is chromia. Poikilocytosis: spherocyte (spherical cells without central pallor, characteristic of hereditary spherocytosis and autoimmune hemolytic anemia); Elliptocytes/Ovalocytes (hereditary elliptocytosis, iron deficiency/megaloblastic anemias); Drepanocytes/Sickle cells** (sickle cell anemia); Codocytes/Target cells (thalassemia, liver disease, heavy metal poisoning); Acanthocytes/Spur cells (severe liver pathology, neuroacanthocytosis, lipid metabolism disorders); Echinocytes/Burr cells(uremia, pyruvate kinase deficiency, or artifact from improper smear drying); Schistocytes/Fragmented cells (DIC syndrome, microangiopathic hemolytic anemias, artificial heart valves); Dacryocytes/Teardrop cells (myelofibrosis, bone marrow metastases, severe anemias). Anisocytosis:Microcytes (< 6.5 μm, iron deficiency, thalassemia); Macrocytes (> 8.0 μm, B12/folate deficiency, liver disease, alcoholism); Megalocytes (> 12.0 μm, severe erythropoiesis disruption, e.g., pernicious anemia). Pathological Inclusions: Howell-Jolly bodies (nuclear chromatin remnants, post-splenectomy or megaloblastic anemia); Cabot rings (nuclear

	membrane remnants, severe erythropoiesis disruption); Basophilic stippling (RNA aggregates, specific marker for lead/heavy metal poisoning); Heinz bodies (denatured hemoglobin, G6PD deficiency under oxidative stress). Osmotic Resistance of Erythrocytes: Normal onset of hemolysis at 0.50–0.45% NaCl, complete hemolysis at 0.40–0.35% NaCl. Decreased resistance (hemolysis at higher NaCl concentrations, e.g., 0.7–0.75%) is seen in non-spherocytic hemolytic anemia and hereditary spherocytosis. Increased resistance is seen in thalassemia and hemoglobinopathies. Transferrin Saturation Coefficient: Normal: 20–50%. LDH (Lactate Dehydrogenase): Marker of ineffective erythropoiesis. Normal: 225–550 U/L; elevated in leukemia, hemolytic anemia, etc. Serum Iron: Normal: 10.6–33.5 µmol/L. Bilirubin and its fractions.
Main Factors Regulating Iron Metabolism:	Ferritin: Normal: 32–68 µg/L (elevated in inflammatory states). Transferrin and TfR (Transferrin Receptors): Key components of the body's iron transport system. Hepcidin: A key peptide hormone produced by the liver, serving as the primary regulator of iron metabolism in the human body. Normal: ~10 ng/mL.
Hemolytic Syndrome: Clinical Triad: Anemia, Hemolytic jaundice, Splenomegaly.	Mechanism: Caused by accelerated hemolysis and premature destruction of erythrocytes. Anemia develops when the rate of destruction exceeds the bone marrow's capacity to produce new erythrocytes. Normal erythrocyte lifespan is 110–120 days; ~0.85% are destroyed and replaced daily. In pathological hemolysis (due to inherited diseases or chronic poisoning by nitrogen oxides, nitrobenzene, sodium nitrite), erythrocyte lifespan is shortened, erythrocyte count drops, and erythropoietin levels rise, stimulating new erythrocyte production. This is indicated by an elevated reticulocyte count (> 2%), increased indirect bilirubin, elevated LDH, and increased urine urobilinogen.
Diagnostic Criteria for Hemolysis:	Jaundice (pallor with a lemon-yellow tint); Reticulocytosis (hyperregenerative anemia); Hyperbilirubinemia (indirect bilirubin); Dark urine; Dark stool (pleiochromia); Splenomegaly; Irritation of the erythroid lineage in bone marrow (erythrokaryocytes > 25%); increased serum iron. Anemia may be microcytic (thalassemia), normocytic, or macrocytic.
Sideropenic Syndrome:	Caused by tissue iron deficiency, leading to decreased activity of many enzymes (cytochrome oxidase, peroxidase, succinate dehydrogenase, etc.). Symptoms Pica (distorted taste): irresistible desire to consume unusual, non-nutritive substances (chalk, toothpaste, coal, clay, sand, ice), as well as raw dough, minced meat, or raw grains. More common in children and adolescents. Muscle weakness and fatigue: Muscle atrophy and decreased strength due to myoglobin and tissue respiration enzyme deficiency.

	Dystrophic changes in skin and appendages: Dryness, scaling, propensity for rapid cracking; dullness, brittleness, hair loss, premature graying; thinning, brittleness, transverse striations, dullness of nails; koilonychia (spoon-shaped concave nails). Angular stomatitis: Cracks or "angular cheilitis" at the corners of the mouth. Trophic changes in the GI mucosa: Dryness of the esophageal mucosa causing difficulty or pain when swallowing dry food (sideropenic dysphagia); development of atrophic gastritis and enteritis. Blue sclerae" symptom:** Bluish tint to the sclera due to impaired collagen synthesis, thinning the sclera and allowing the underlying vascular choroid to show through. Decreased reparative processes in skin and mucous membranes.
Anemic Syndrome:	A pathological state characterized by a decrease in erythrocyte count and hemoglobin content per unit volume of blood. Manifested by non-specific and specific symptoms. Non-specific symptoms are due to hypoxia (weakness, dizziness, tachycardia, exertional dyspnea, tinnitus). Specific symptoms depend on the form of anemia.
Hemorrhagic Syndrome:	A clinical manifestation of the body's tendency toward recurrent bleeding and hemorrhages into the skin or internal organs of one or multiple localizations, either triggered by minor trauma or occurring spontaneously. Diseases clinically characterized by hemorrhagic syndrome are grouped under hemorrhagic diatheses. They are divided into coagulopathies (hemophilia, etc.), thrombocytopathies (Werlhof's disease / ITP, etc.), and vasculopathies (Henoch-Schönlein purpura / IgA vasculitis, etc.).
Types of Bleeding	1. **Hematoma type:** Characterized by deep hematomas in joints (hemarthrosis), soft tissues, and muscles, appearing after minor trauma or impacts. Hemorrhages cause tissue destruction, deforming arthrosis, contractures, pathological fractures, and muscle atrophy. *Disproportionate to trauma:* bleeding/hematomas are much larger and more severe than the inciting injury. *Delayed bleeding:* hemorrhages typically do not occur immediately but hours or days later (slow clot formation). *Risk of compression:* large hematomas can compress vessels and nerves, causing pain. Almost exclusively characteristic of hereditary coagulopathies (Hemophilia A and B). 2. Petechial-microcirculatory type: Characterized by painless, non-tense (do not compress surrounding tissues), superficial hemorrhages into the skin and mucous membranes, petechiae, bruises, gingival, and uterine bleeding. Hemorrhages result from minor trauma to microvessels (e.g., during blood pressure measurement, palpation, or rubbing the skin). Hemarthrosis and deep hematomas are not typical. Bleeding after cavity surgeries is rare and not prone to recurrence. Observed in thrombocytopenias and thrombocytopathies. 3. Mixed microcirculatory-hematoma type: Characterized by a combination of fine petechial rash/bruising with the appearance of

	separate, often painful hematomas in subcutaneous tissue or muscles. Joint hemorrhages are rare and do not lead to deforming arthrosis or muscle atrophy. Hematomas, depending on localization, may mimic an acute abdomen, bowel obstruction, or acute appendicitis. Epistaxis, mucosal bleeding, and heavy menstruation are possible. Observed in von Willebrand disease (impaired platelet adhesion and factor VIII deficiency), DIC syndrome, anticoagulant overdose, and severe deficiency of individual prothrombin complex plasma factors. 4. Vasculitic-purpuric type: Encompasses all hemorrhages caused by inflammation in microvessels. Hemorrhages occur against a background of local exudative-inflammatory phenomena and general immunoallergic or infectious-toxic disorders. The hemorrhagic rash on the skin is symmetrical (on both limbs and trunk), slightly elevated above the skin level due to inflammatory infiltration and edema. The rash is often preceded by itchy, small indurations, which later acquire a purpuric appearance due to blood extravasation. After the rash resolves, prolonged hyperpigmentation remains (other bleeding types do not leave this). Observed in hemorrhagic vasculitis. 5. Angiomatous type: Characterized by the absence of spontaneous or post-traumatic hemorrhages into the skin, subcutaneous tissue, or other organs, but features constant bleeding from 1–2 specific locations (epistaxis, less commonly pulmonary, gastrointestinal, or hematuria). Observed in various types of telangiectasias.
Hyperplastic / Proliferative Syndrome:	Caused by leukemic infiltration of blast cells into lymph nodes, liver, spleen, kidneys, myocardium, lungs, and other organs (as a consequence of leukemia).
Variants of Hyperplastic Syndrome:	Lymphadenopathy (regional or generalized): lymph nodes are dense, painless on palpation, not matted to each other or surrounding tissues; most commonly enlarged are posterior cervical, anterior cervical, and submandibular nodes, less commonly inguinal, axillary, and mediastinal nodes. (Mediastinal lymphadenopathy often presents with compression syndrome: dyspnea, skin cyanosis, neck swelling, and distension/pulsation of vessels). Ulcerative-necrotic syndrome + tonsillar hyperplasia:** Ulcerative-necrotic changes in the oral cavity caused by infiltration of the mucosa and submucosa by blast cells. Leukemids: Infiltration of the skin by leukemic cells in the form of reddish-blue papular plaques. Characteristic of myeloblastic leukemia. Hepatosplenomegaly (most characteristic of Acute Lymphoblastic Leukemia, ALL).

5. Theoretical Questions Considered in the Lesson

1. Features of hematopoiesis in children.
2. Anatomical and physiological features (APF) of bone marrow in childhood.

3. Features of the erythrocytic lineage of the blood system in children.
4. Features of the leukocytic lineage of the blood system in children.
5. Criteria for evaluating (analyzing) the peripheral blood of a healthy child depending on age.
6. Features of the myelogram.
7. Features of hemostasis in the age aspect.
8. Age-related changes in hemoglobin.
9. Criteria for evaluating (analyzing) the peripheral blood of a sick child depending on age.
10. Erythrocyte indices, normal values.
11. Anemic syndrome, sideropenic syndrome, iron deficiency anemia.
12. Semiotics of hemolytic syndrome.
13. Semiotics of hemorrhagic syndrome.
14. Semiotics of proliferative syndrome.

Recommended Literature

Basic:

1. Nelson Textbook of Pediatrics (Robert M. Kliegman et al., 22nd Edition, 2024). Published by Elsevier.
2. Propaedeutics of Pediatrics in Syndromes*. Boyarchuk O.R., Kinash M.I. Ukrmedknyha, 2022. 760 p.
3. Propaedeutics of Childhood Diseases with Child Care* (T. V. Kapitan, 5th ed., 2021). Vinnytsia. 832 p.

Additional:

1. Nelson Essentials of Pediatrics* / Karen J. Marcdante, Robert M. Kliegman; translation of the 8th English edition in 2 volumes. Scientific editors of the translation: V.S. Berezenko, T.V. Pochynok. Kyiv: VSV "Medicine", 2020.
2. Manual of Propaedeutic Pediatrics / Lectures on Propaedeutic Pediatrics*. Nikitiuk S.O. Ukrmedknyha. English, 2020.

Methodological development composed by Assoc. Prof. Grishchenko N.