MANAGEMENT
OF CHILDHOOD HYPERTENSION

Learning gude for 5th and 6th-year students specializing in Medicine and Pediatrics, medical interns, pediatricians, and general practitioners–family doctors

МІНІСТЕРСТВО ОХОРОНИ ЗДОРОВ'Я УКРАЇНИ
Харківський національний медичний університет

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ТАКТИКА ВЕДЕННЯ ТА ЛІКУВАННЯ АРТЕРІАЛЬНОЇ ГІПЕРТЕНЗІЇ У ДІТЕЙ

Методичні вказівки для здобувачів вищої освіти 5–6-х курсів за спеціальністю «Медицина» та «Педіатрія», лікарів-інтернів, лікарів-педіатрів, лікарів загальної практики – сімейної медицини

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M .K. Uryvaieva
A. S. Senatorova

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Упорядники М. О. Гончарь
М. К. Уриваєва
А. С. Сенаторова

TABLE OF CONTENTS

INTRODUCTION

Arterial hypertension (AH) in children is a significant medical and social problem due to its potential to progress into adulthood, leading to cardiovascular diseases, kidney damage, and other complications. Understanding its causes, diagnosis, and treatment strategies is crucial for pediatricians and general practitioners.

DEFINITION AND CLASSIFICATION

Arterial hypertension in children is defined as a persistent increase in blood pressure above the 95th percentile for age, sex, and height on three or more occasions. It is classified as:

- Primary (essential) hypertension – No identifiable cause, often associated with genetic and lifestyle factors.
- Secondary hypertension – Due to underlying conditions such as kidney disease, endocrine disorders, or cardiovascular anomalies.

RISK FACTORS AND PATHOGENESIS

- Genetic predisposition
- Obesity and poor dietary habits
- Sedentary lifestyle
- Kidney diseases
- Endocrine disorders (e.g., hyperthyroidism, Cushing's syndrome)
- Chronic stress

The pathogenesis of AH involves increased vascular resistance, sodium retention, and neurohormonal dysregulation.

CLINICAL MANIFESTATIONS

- Asymptomatic in early stages
- Headaches, dizziness
- Fatigue, irritability
- Nosebleeds
- Changes in vision (blurred vision, double vision)

DIAGNOSTIC CRITERIA AND EXAMINATION METHODS

- Blood pressure measurement: At least three measurements on different days using an appropriately sized cuff
- Urinalysis, blood tests: To detect secondary causes
- Ultrasound of kidneys: To assess for structural abnormalities
- ECG, Echocardiography: To evaluate heart function
- Ambulatory blood pressure monitoring (ABPM): To identify white-coat hypertension and nocturnal patterns

PRINCIPLES OF TREATMENT

- Lifestyle modifications (primary approach)
  - Healthy diet (low salt, high in fruits and vegetables)
  - Regular physical activity
  - Weight management
  - Stress reduction techniques
- Medication therapy (in severe cases or secondary AH)
  - ACE inhibitors (e.g., enalapril)
  - Calcium channel blockers (e.g., amlodipine)
  - Beta-blockers (in specific cases)

PREVENTION AND PROGNOSIS

Early diagnosis and intervention significantly improve prognosis. Regular blood pressure monitoring, healthy lifestyle promotion, and early identification of risk factors are key to preventing complications.

PRACTICAL RECOMMENDATIONS FOR PHYSICIANS

1. Always use age-appropriate blood pressure charts.
2. Investigate secondary causes in cases of severe or resistant hypertension.
3. Educate parents and children on lifestyle modifications.
4. Monitor patients regularly and adjust treatment as necessary.

CONCLUSION

Arterial hypertension in children requires timely diagnosis and a comprehensive approach to management. Primary care physicians play a crucial role in identifying and treating this condition to prevent long-term complications.

List of Abbreviations

HTN – Hypertension
BP – Blood Pressure
AAP – American Academy of Pediatrics
ABPM – Ambulatory Blood Pressure Monitoring
HD – Hypertensive Disease
DBP – Diastolic Blood Pressure
24h BPM – 24-hour Blood Pressure Monitoring
ECG – Electrocardiography
TC – Total Cholesterol
ECHO – Echocardiography
CT – Computed Tomography
SBP – Systolic Blood Pressure
ICD – International Classification of Diseases
ALT – Alanine Aminotransferase
AST – Aspartate Aminotransferase
GFR – Glomerular Filtration Rate
U/S – Ultrasound
LV – Left Ventricle

RELEVANCE

The issue of arterial hypertension (AH) in our country is attracting the close attention of not only general practitioners and cardiologists but also pediatricians. This is due to the fact that primary hypertension has become significantly more common among children, especially adolescents.

The prevalence of primary hypertension among schoolchildren ranges from 1 % to 18 %. Over the next 3–7 years, elevated blood pressure (BP) persists in 33–42 % of adolescents, and in 17–26 % of cases, it progresses to hypertensive disease. Studies have shown that early detection of pathological trends leading to hypertension in children and adolescents, along with timely correction of cardiovascular disorders, can positively impact the overall health of the population. The strong link between high blood pressure and the future development of hypertensive disease requires careful attention to every instance of elevated blood pressure in children.

Therefore, improving the organization of medical care for children with hypertension by implementing modern standardized approaches based on evidence-based medicine is a priority for the healthcare system.

In recent decades, significant progress has been made in managing pediatric hypertension. Numerous large-scale, multicenter studies have been conducted, allowing for the optimization of approaches to diagnosing and managing hypertension in children and adolescents.

According to epidemiological studies cited by experts from the American Academy of Pediatrics (AAP), the prevalence of hypertension among children with a normal body mass index is approximately 3.5 %. In contrast, among overweight and obese children, the incidence rises to 24.8 %. Additionally, among children born with low birth weight, 7.3 % develop hypertension, while in children with obstructive sleep apnea syndrome, the prevalence reaches 14 %.

This methodological guide presents data based on global recommendations for pediatric hypertension management, including Clinical Guideline 00578 (blood pressure measurement in children), Guideline 00609 ("Hypertension: Examination and Treatment Strategies"), and other guidelines, along with materials from the online resource UpToDate and the American Academy of Pediatrics (AAP, 2017).

DEFINITIONS

Arterial Hypertension (AH) – a condition in which the average level of systolic and/or diastolic blood pressure, calculated based on three separate measurements, is equal to or exceeds the 95th percentile of the blood pressure distribution curve in a population of the same age, gender, and height. Arterial hypertension can be **primary (essential)** or **secondary (symptomatic)**.

The term **arterial hypertension** comes from the Greek words *hyper* (meaning "above" or "excessive") and *tonos* (meaning "tension" or "pressure"), indicating excessive pressure exerted by blood on the arterial walls from within.

Primary or Essential Hypertension – an independent disease in which the main clinical symptom is elevated systolic and/or diastolic blood pressure with no identifiable cause.

Hypertensive Disease (HD) – a chronic condition characterized by arterial hypertension but not associated with specific pathological processes known to cause increased blood pressure (which would indicate secondary or symptomatic hypertension).

The diagnosis of arterial hypertension is established according to the **ICD-10 classification (I10)** and the recommendations of the **Ukrainian Association of Cardiologists** for the prevention and treatment of hypertension (2016), as well as guidelines from the **American Academy of Pediatrics (AAP, 2017)**.

PATHOGENESIS

The main physical factors that influence blood pressure include:

- The speed and force of blood pumping by the left ventricle (heart rate);
- The volume of blood in the human body;
- Systemic vascular resistance (resistance of blood vessels), which in turn depends on the following factors: vessel radius, vessel length, blood viscosity, and the smoothness of blood vessel walls.

Currently, three mechanisms of endogenous blood pressure regulation are well-characterized:

1. **Baroreceptor Reflex** – Baroreceptors detect changes in blood pressure and send signals to the medulla oblongata, specifically to the ventrolateral neurons. The brain, through the autonomic nervous system, regulates blood pressure by adjusting both the force and rate of heart contractions, as well as overall peripheral resistance. The most important baroreceptors are located in the left and right carotid sinuses and the aortic arch.

2. **Renin-Angiotensin System (RAS)** – This system ensures the long-term regulation of blood pressure by allowing the kidneys to compensate for blood volume losses or significantly reduce blood pressure through the activation of the endogenous vasoconstrictor angiotensin II.

3. **Aldosterone Release:** This steroid hormone is released from the adrenal cortex in response to angiotensin II or elevated potassium levels in the blood serum. Aldosterone leads to sodium retention and potassium excretion through the kidneys. Since sodium is the primary ion that determines fluid levels in blood vessels via osmosis, aldosterone increases both fluid retention and, indirectly, blood pressure.

CLASSIFICATION

Classification of Secondary Arterial Hypertension in Children

1. Arterial Hypertension of Nephrogenic Origin:

A. Renoparenchymal Hypertension:

- Acute glomerulonephritis
- Subacute malignant glomerulonephritis
- Chronic glomerulonephritis
- Interstitial nephritis
- Kidney tuberculosis
- Chronic pyelonephritis
- Obstructive uropathies (hydronephrosis, megaureter, kidney stones)
- Vesicoureteral reflux complicated by reflux nephropathy
- Acute kidney injury (AKI)
- Chronic kidney disease (CKD)
- Congenital kidney anomalies (aplasia, hypoplastic dysplasia, ectopia)
- Kidney damage in systemic connective and musculoskeletal tissue diseases (systemic lupus erythematosus, dermatomyositis, rheumatoid arthritis)
- Kidney tumors (Wilms tumor, plasmacytoma, angiosarcoma), retroperitoneal lymph node reticulosarcoma with kidney invasion
- Kidney injury with perirenal hematoma formation

B. Renovascular Hypertension:

- Renal vein thrombosis
- Anomalies in the number, length, and position of renal vessels

- Extravascular compression of renal vessels
- Mixed (vascular-parenchymal) hypertension
- Systemic vasculitis with kidney involvement (polyarteritis nodosa, Wegener's granulomatosis, Kawasaki syndrome, Goodpasture syndrome, Henoch-Schönlein purpura)
- Polycystic kidney disease
- Nephroptosis (congenital and post-traumatic)

2. Arterial Hypertension Caused by Diseases of the Heart and Great Vessels (Cardiovascular and Hemodynamic):

- Coarctation of the aorta
- Aortic valve insufficiency
- Complete atrioventricular block
- Long-standing atrial septal defect

3. Arterial Hypertension Associated with Diseases of the Endocrine System:

- Cushing's disease
- Primary hyperaldosteronism (Conn's syndrome)
- Corticosteroma (Cushing's syndrome)
- Pheochromocytoma, pheochromoblastoma
- Chromaffin tumors located outside the adrenal glands
- Hyperthyroidism
- Diabetes mellitus (membranous nephropathy, diabetic glomerulosclerosis)
- Adrenogenital syndrome, hypertensive form

4. Arterial Hypertension Associated with Diseases of the Central Nervous System:

- Brain tumors
- Brain injuries
- Poliomyelitis, bulbar form
- Encephalitis with involvement of the diencephalon
- Diencephalic hypertensive syndrome of Peidys
- Hormonal crisis of puberty (juvenile hypertension)
- Psychoemotional stress

5. Arterial Hypertension Due to Metabolic Disorders:

- Hepatic porphyrias (acute intermittent porphyria, hereditary coproporphyria)
- Hypercalcemia
- Familial hypercholesterolemia
- Hypernatremia

6. Arterial Hypertension Due to Rare Diseases and Syndromes:

- Guillain-Barre syndrome
- Gasser syndrome
- Mashkovitz syndrome
- Liddle's syndrome (pseudohyperaldosteronism)

- Pickwick syndrome
- Barre-Masson syndrome
- Grönblad-Strandberg syndrome (elastic pseudoxanthoma)
- Said-Louren's syndrome

7. Drug-Induced Arterial Hypertension, Associated with the Use of:

- High-dose glucocorticosteroids (exogenous hypercorticism)
- Erythropoietin
- Cyclosporin A (Sandimmun Neoral)
- Vitamin D overdose and development of pyelonephritis
- Nonsteroidal anti-inflammatory drugs (Movalis)

8. Arterial Hypertension Due to Poisoning:

- Household neurotoxic organophosphate compounds (chlorophos, carbofos, phosphatide, etc.).
- Neuro- and psychotropic inorganic lead compounds (tetraethyl lead, lead oxide, etc.), water-soluble barium salts.
- Mercury vapor, leading to the development of necrotic nephrosis.

In pediatric practice, various recommendations for determining the category of elevated blood pressure are currently used. Some of them consider the dependence of blood pressure on age, sex, height, weight index, some are screening, some use the term "prehypertension," however, the recommendations of the American Academy of Pediatrics (AAP), consistent with the guidelines of the American Heart Association and the American College of Cardiology for adult patients (PK Whelton, RM Carey, WS Aronow et al., 2019), propose new criteria for determining blood pressure categories in children and the severity of arterial hypertension (*table 1*).

Table 1

Classification of AH in children and adolescents (according to percentile by age, sex, and height)

New criteria for determining blood pressure categories and degrees of severity of arterial hypertension in children

Category	Children aged 1–13 years	Children aged 13 and older
Normal BP	< 90th percentile	< 120/< 80 mm Hg
Elevated BP	≥ 90th percentile to 95th percentile or 120/80 mm Hg to 95th percentile (whichever is lower)	120/< 80 to 129/80 mm Hg
Stage 1 AH	≥ 95th percentile to < 95th percentile + 12 mm Hg or 130/80 to 139/89 mm Hg (whichever is lower)	130/< 80 to 139/89 mm Hg
Stage 2 AH	≥ 95th percentile + 12 mm Hg or 140/90 mm Hg (whichever is lower)	≥140/90 mm Hg

Notes: AH – arterial hypertension, BP – blood pressure.

These recommendations offer the simplest interpretation of BP values for children aged 13 and older. In both adults and children aged 13 and older, the appearance of pressure indicators above 120/80 mm Hg should alert clinicians to possible AH. For children under 13, a similar figure is represented by the indicators presented in *Table 1*, corresponding to the 90th percentile of BP in a particular age category.

This *table 2* can be used for preliminary screening of patients to identify children who require further evaluation.

Table 2

Approximate values of SBP and DBP in children, at which further examination is necessary to diagnose high blood pressure and hypertension (90th percentile)

Age, years	Boys		Girls	
	Systolic BP, mm Hg	Diastolic BP, mm Hg	Systolic BP, mm Hg	Diastolic BP, mm Hg
1	98	52	98	54
2	100	55	101	58
3	101	58	102	60
4	102	60	103	62
5	103	63	104	64
6	105	66	105	67
7	106	68	106	68
8	107	69	107	69
9	107	70	108	71
10	108	72	109	72
11	110	74	111	74
12	113	75	114	75
≥ 13	120	80	120	80
Notes: DBP– Diastolic Blood Pressure; SBP – Systolic Blood Pressure				

PROGRESSION AND SEVERITY OF HYPERTENSION

Course of Hypertension

Hypertension can be categorized as either labile or stable. Information about the course of hypertension helps in planning the monitoring of the child (whether on an outpatient or inpatient basis) and in predicting the future development of hypertensive disease.

- **Labile hypertension** is characterized by unstable, periodic increases in blood pressure (above the 95th percentile), often systolic, primarily during the day. According to ambulatory blood pressure monitoring (ABPM), the hypertension time index is higher than 25 % but lower than 5 0%, with increased blood pressure variability.

- **Stable hypertension** is characterized by a persistent increase in blood pressure, both systolic and often diastolic (above the 95th percentile).

Severity Levels of Hypertension

- **Stage I Hypertension:** Blood pressure is above the 95th percentile but below the 95th percentile + 10 mmHg. According to ABPM, the hypertension time index predominantly reaches 60-80% during the day.
- **Stage II Hypertension:** Blood pressure exceeds the 95th percentile + + 10 mm Hg. According to ABPM, the average daily systolic and diastolic blood pressure exceeds the 95th percentile + 10 mm Hg, and the hypertension time index is 80–100 %.

Hypertensive Disease

Hypertensive disease is diagnosed in children after 16 years of age, when hypertension persists for more than a year, and signs of target organ damage are detected (left ventricular hypertrophy, cerebral angiopathy, microalbuminuria).

The Role of Ambulatory Blood Pressure Monitoring (ABPM)

ABPM is increasingly used in the diagnosis of hypertension due to its ability to record multiple blood pressure readings over a 24-hour period while the child engages in their usual activities.

According to ABPM findings, recommendations have been published regarding the classification of patients based on office and ambulatory blood pressure measurements, which include the following:

1. **Prehypertension:** Office systolic blood pressure (SBP) or diastolic blood pressure (DBP) is greater than the 90th percentile but less than the 95th percentile. Average ambulatory SBP or DBP is less than the 95th percentile, and the ambulatory SBP or DBP load is 25 to 50 %.
2. **Ambulatory Hypertension:** Office blood pressure is greater than the 95th percentile. Average ambulatory SBP or DBP is at the 95th percentile, and the SBP or DBP load is 25 to 50 %.
3. **Stage I Hypertension (risk of target organ damage):** Elevated SBP and/or DBP is greater than or equal to the 95th percentile but less than the 99th percentile + 5 mm Hg (confirmed during the last 3 visits). ABPM criteria: the average daily SBP/DBP and/or average daytime and/or average nighttime readings are greater than or equal to the 95th percentile. The hypertension time index is 60–80 %.
4. **Stage II Hypertension (risk of target organ damage):** Elevated SBP is greater than the 99th percentile + 5 mm Hg (confirmed during the last 3 visits). ABPM criteria: the average daily SBP/DBP and/or average daytime and/or average nighttime readings are greater than or equal to the 95th percentile. The hypertension time index is 80–100 %.
5. **Stage I Hypertensive Disease (age ≥ 16 years):** Stage II hypertension lasting more than 1 year without target organ damage.
6. **Stage II Hypertensive Disease (Stage 2 Hypertension)** lasting more than 1 year with target organ damage (left ventricular hypertrophy, cerebral angiopathy, microalbuminuria).

If systolic and diastolic blood pressure fall into different categories (for example, systolic BP – Stage II hypertension, diastolic BP – Stage I hypertension, or systolic BP – Stage I hypertension, diastolic BP – normal), the hypertension stage is determined by the higher of the two levels.

Screening values for elevated blood pressure are also used, especially convenient for mass examinations of healthy children (*Table 3*).

Table **3**

Screening Threshold Blood Pressure Values in Children

Age (Years)	*Screening Threshold Values (mm Hg)*
> 1 years	110/65
1–5	115/75
6–10	125/85
11–18	140/90

CLINICAL PRESENTATION OF HYPERTENSION

The clinical picture of hypertension depends on the child's age, the presence of concomitant diseases and possible complications, the time of detection, and the state of the patient's compensatory mechanisms. The symptoms and signs of hypertension can be subtle, especially in infants and young children, and conversely, the leading symptom may be the development of a complication in the form of acute emergencies.

Complaints of children with hypertension are most often determined by damage to target organs in the form of headache, dizziness, nosebleeds, episodes of loss of consciousness or seizures (against the background of a hypertensive crisis), as well as nonspecific manifestations of asthenic and vegetative syndromes.

With heart damage, children complain of chest pain, a feeling of rapid heartbeat, shortness of breath at rest and during physical exertion, swelling of the lower extremities, and an increase in the abdomen with the development of ascites.

With kidney damage, complaints may be absent for a long time, while in the clinical urine analysis, changes in color and amount may be noted with the development of dysuria, edema, disorders of the musculoskeletal system, and the development of anemia.

In young children, complaints are most often nonspecific: parents pay attention to impaired development of the child, refusal to eat, agitation, fatigue, sleep disturbances and delayed motor skills, speech, and other symptoms that most often dominate in the clinic of secondary arterial hypertension.

The collection of a history of the disease and life makes it possible to clarify the features of the family history to establish possible hereditary causes of hypertension: the presence of hypertension, coronary heart disease or stroke, diabetes mellitus, dyslipidemia, obesity, hereditary kidney diseases (polycystic kidney disease), endocrine diseases (pheochromocytoma, Cushing's disease or syndrome, etc.) in close relatives.

The child's medical history involves obtaining information about body weight and gestational age at birth (premature birth and low birth weight are associated with the development of hypertension), bad habits (smoking, alcohol consumption, caffeine, and other psychostimulants), the presence of chronic diseases that may be associated with the development of hypertension (chronic kidney disease, diabetes mellitus, hyperthyroidism), obstructive sleep apnea syndrome.

During the objective examination of a child with hypertension, the following are performed: assessment of physical development using percentile tables, calculation of BMI, determination of waist circumference, measurement of blood pressure on four limbs, auscultation of the heart, lungs, aorta, neck vessels, projection of renal arteries, palpation of the abdominal organs, assessment of neurological status.

During the physical examination of a patient with hypertension, attention should be paid to those signs that may indicate the etiology of hypertension (*Table 4)*.

Table 4

Genitals Virilization Adrenogenital syndrome

Physical Examination	Signs	Potential Etiological Factor of Hypertension
Physical Measures	Tachycardia	Hyperthyroidism, Pheochromocytoma, Neuroblastoma, Essential (Primary) Hypertension
	Decreased pulsation of arteries in the lower extremities; Blood pressure in the lower extremities is the same or lower than in the upper extremities	Coarctation of the aorta
Eyes	Hypertensive retinopathy	Severe form of hypertension, most likely secondary hypertension
ENT (Ears, Nose, Throat)	Adenotonsillar Hyperplasia	Obstructive sleep apnea syndrome
Growth/Bood Mass	Growth Retardation	Chronic Kidney Disease
	Abdominal Obesity	Cushing`s syndrome, metabolic syndrome
Head and neck	Moon face	Cushing`s syndrome
	"Elf" face	Syndrome Williams
	Webbed Neck	Shereshevsky-Turner syndrome (characteristic of both primary and secondary hypertension due to coarctation of the aorta or kidney malformation)
	Enlarged Thyroid Gland	Hyperthyroidism
Skin	Pallor/hyperemia, profuse sweating	Pheochromocytoma
	Acne, hirsutism, striae	Cushing's syndrome, anabolic steroid abuse
	Cafe-fu-lait spots	Neurofibromatosis
	Erythema on the face of the "butterfly" type	Systemic lupus erythematosus with kidney damage
	Acanthosis nigricans (dark, velvety, skin in folds)	Metabolic syndrome, type 2 diabetes

Physical Examination	Signs	Potential Etiological Factor of Hypertension
Chest	Widely set nipples	Shereshevsky-Turner syndrome. Left ventricular hypertrophy
	Displacement of the apical impulse (heartbeat felt further down and to the left)	Left ventricular hypertrophy
	Heart murmur in the area between shoulder blades	Coarctation of the aorta
Abdomen	Abdominal mass	Pheochromocytoma, neuroblastoma, pulmonary stenosis
	Abdominal bruit (sound heard with a stethoscope) in the epigastric region or left/right flank	Renovascular hypertension (narrowing of renal arteries)
	Enlarged kidneus upon palpation	Polycystic kidney disease, kidney tumor
Genitals	Virilization (masculinization in females)	Adrenogenital syndrome

TECHNIQUE FOR MEASURING BLOOD PRESSURE AND INTERPRETATION OF RESULTS

We consider it advisable to describe the technique of blood pressure measurement in children, as proper implementation affects the research results and determines the further tactics of the child's examination.

Blood pressure is measured using devices called tonometers; both mechanical and electronic types exist. The devices are equipped with cuffs that are placed on the arm (used for examining children) or with wrist sensors.

A device prepared for operation consists of a cuff that is filled with air, a measuring device (a manometer), a bulb with a valve; a phonendoscope is necessary to conduct the examination.

It is necessary to pay attention to the use of age-appropriate cuffs of various widths.

The width of the cuff should be two-thirds of the length of the arm when blood pressure is measured on the right arm. The same cuff can be used when measurements are taken from the lower leg. If measurements are carried out on the thigh, the cuff width should be two-thirds of the length of the thigh. Choosing a wider cuff is better than choosing a too narrow one.

The peculiarities of measurement in children lie in the fact that the circumference of the arm in children changes with age, it is necessary to use tonometers with a set of cuffs of different sizes (for a newborn – 5–7.5 cm; for infants – 7.5–13 cm; up to 12 years – 13–20 cm).

Methodology: ILLUSTRATIONS!

1. The cuff is placed on the bare arm (the lower edge of the cuff is located 2–3 cm above the elbow crease) not too tightly (1–2 fingers of the patient can be placed under the cuff);

2. In the area of the elbow bend, the pulsation of the ulnar artery is palpated and the head of the phonendoscope is applied to this place;

3. Air is gradually pumped into the cuff with the bulb.

4. Through the phonendoscope, the pulsation of the blood is carefully listened to, the moment when the sound disappears is noted.

5. A couple more pumps are made with the bulb, and then, opening the valve, the air pressure in the cuff is gradually lowered.

6. The readings of the manometer are recorded when the first sound strike appears, they correspond to the value of systolic pressure.

7. With a further decrease in pressure in the cuff, the sound tones gradually weaken.

8. The values of the manometer are recorded at the moment of their disappearance, they correspond to the value of diastolic pressure.

Diagnosis of systemic hypertension should be based on repeated blood pressure measurements over several days. Blood pressure on the right arm should be measured at least three times. Diastolic pressure is determined as the disappearance of Korotkoff sounds (K.5). If the sounds do not disappear, the point at which they soften (K4) is recorded.

Oscillometric devices for measuring pressure may give slightly different blood pressure values compared to a sphygmomanometer (which is the standard method). Therefore, sphygmomanometers should be used, at least in borderline cases.

Crying raises blood pressure. Sometimes it is necessary to take measures that allow measuring pressure, for example, when the child is asleep.

Usually, blood pressure is always measured on the thigh (with a sphygmomanometer) or lower leg to rule out or confirm coarctation of the aorta.

Based on the blood pressure measurement results, children with blood pressure values less than the 90th percentile require blood pressure measurement once a year during preventive examinations, regardless of the presence of complaints.

Children whose indicators correspond to high blood pressure require observation, which involves repeated blood pressure measurement at 6-month intervals. If such indicators persist for a year, the child should undergo ambulatory blood pressure monitoring (ABPM) and be referred to specialists.

It should be noted that even in these categories, counseling on lifestyle changes (primarily weight normalization and dietary recommendations) is already recommended.

If the child's blood pressure indicators at the first visit correspond to grade 1 hypertension, repeated blood pressure measurement is performed in a shorter period (in 1–2 weeks), and if such indicators persist for 3 months, ABPM is performed and medication treatment is started.

When obtaining blood pressure indicators that correspond to grade 2 hypertension, the decision on conducting ABPM and prescribing medication is made within one week.

According to the recommendations of the European Society of Hypertension and the European Society of Cardiology (2019), indications for ABPM in children include measurements necessary for diagnosis, assessment during

treatment, as well as in the case of clinical trials and other conditions in which the presence of orthostatic variation in blood pressure or its rapid and episodic increase is difficult to detect during a visit to the doctor. In addition, ABPM provides important information about the state of cardiovascular regulation mechanisms, allows determining **the daily rhythm of blood pressure, nocturnal hypotension and hypertension, the dynamics of blood pressure over time, and the uniformity of the antihypertensive effect** of drugs. Thanks to blood pressure monitoring, it has been established that with a normal daily rhythm, blood pressure reaches its minimum around 3:00–4:00 at night, then gradually rises to 5:00–6:00 in the morning and begins to increase sharply about an hour before waking up.

Ambulatory blood pressure monitoring (ABPM) is the optimal method for children and has no contraindications. Known complications include swelling of the forearm and wrist, petechial hemorrhages, and contact dermatitis. To prevent petechial hemorrhages, ABPM should not be performed on children with thrombocytopenia, thrombocytopathy, and other disorders of vascular-platelet hemostasis during the acute period. To prevent the development of swelling of the distal part of the limb and contact dermatitis, the cuff should be applied not to the bare shoulder, but to the sleeve of a thin shirt. The outlet tube of the device should be directed upwards so that the patient can put on other clothes over the cuff if necessary.

Compared with office and home measurements, ABPM has significant advantages, as it allows for the diagnosis of white coat hypertension and masked hypertension, allows for the determination of nighttime blood pressure and blood pressure in real-world conditions of the child's life, and has prognostic value for the risk of complications of arterial hypertension.

When analyzing data obtained during ABPM, the following groups of parameters are the most informative:

- Average blood pressure values (systolic, diastolic, pulse, and mean hemodynamic) for the day, day and night allow for understanding information about the level of blood pressure;
- Maximum and minimum blood pressure values at different times of the day allow for diagnosing hypertension (blood pressure above the 95th percentile) and hypotension (below the 10th percentile);
- Indicators of "pressure load" (hypertension time index, hypertension area index) for the day, day and night (quantitative assessment of episodes of elevated or lowered blood pressure);
- Blood pressure variability (assessment of deviations of blood pressure from the curve of the daily rhythm);
- Daily index (degree of nocturnal decrease in blood pressure) shows the difference between average daily and nighttime blood pressure values as a percentage of the daily average value;

- The magnitude and rate of the morning rise in blood pressure are assessed by the difference between the maximum and minimum blood pressure in the period from 4 to 10 am. The rate of the morning rise in blood pressure is assessed by the ratio of the magnitude and time of the blood pressure rise.

A rapid morning rise in blood pressure is an unfavorable prognostic sign of the development of complications in hypertension.

- Duration of hypotonic episodes (hypotension time index and hypotension area index) at different times of the day.

PATIENT EXAMINATION METHODS

1. An evaluation of the results of diagnostic measures performed at primary care facilities is conducted.
2. Medical history collection, physical examination, and testing are aimed at identifying signs of secondary hypertension, clarifying the degree of target organ damage, the presence of comorbidities and risk factors.
3. During the physical examination, the following are performed: blood pressure measurement on both arms, auscultation of the heart, lungs, aorta, neck vessels, projection of the renal arteries, palpation of the abdominal organs, and assessment of neurological status. Blood pressure measurement on the legs is performed if it has not been done previously.
4. Consultations with specialists are conducted in accordance with the predominant manifestations of hypertension complications, existing risk factors, and comorbidities.
5. The list of examinations includes mandatory laboratory tests:
   - Complete blood count
   - Complete urine analysis, supplemented by microalbuminuria determination
   - Blood glucose level, uric acid, total cholesterol and lipid profile, ALT, AST, bilirubin; serum potassium and sodium, creatinine with eGFR calculation using the **CKD-EPI formula.**

CKD-EPI Formula:

$$eGFR = 141 \times \min(Scr/\kappa, 1)^{\alpha} \times \max(Scr/\kappa, 1)^{-1.209} \times 0.993^{Age} \times \times 1.018 \text{ (if female)} \times 1.159 \text{ (if Black)}$$

Where Scr is serum creatinine in mg/dL, $\kappa = 0.7$ for females and 0.9 for males, $\alpha = -0.329$ for females and -0.411 for males, min = minimum of Scr/κ or 1, and max = maximum of Scr/κ or 1.

Note: Calculations are performed using special computer programs, smartphone and tablet applications, or online.

In cases where it is necessary to urgently determine eGFR and there is no possibility to calculate eGFR using the CKD-EPI formula, calculation using the Cockcroft-Gault formula is allowed with subsequent calculation of eGFR using the CKD-EPI formula in the future.

Cockcroft-Gault Formula:

eGFR = [(140 – Age) × (Body weight) / 72 × (Serum creatinine)] × (0.85 if female)

Where body weight is expressed in kg, age in years, and serum creatinine in mg/dL.

INSTRUMENTAL EXAMINATION METHODS

Mandatory Instrumental Examinations:

- ECG (Electrocardiogram) in 12 standard leads;
- Echocardiography (EchoCG, DopplerCG);

For the purpose of detecting changes in the heart in hypertension, echocardiography with determination of left ventricular myocardial mass (LVM), relative wall thickness, and contractility is recommended.

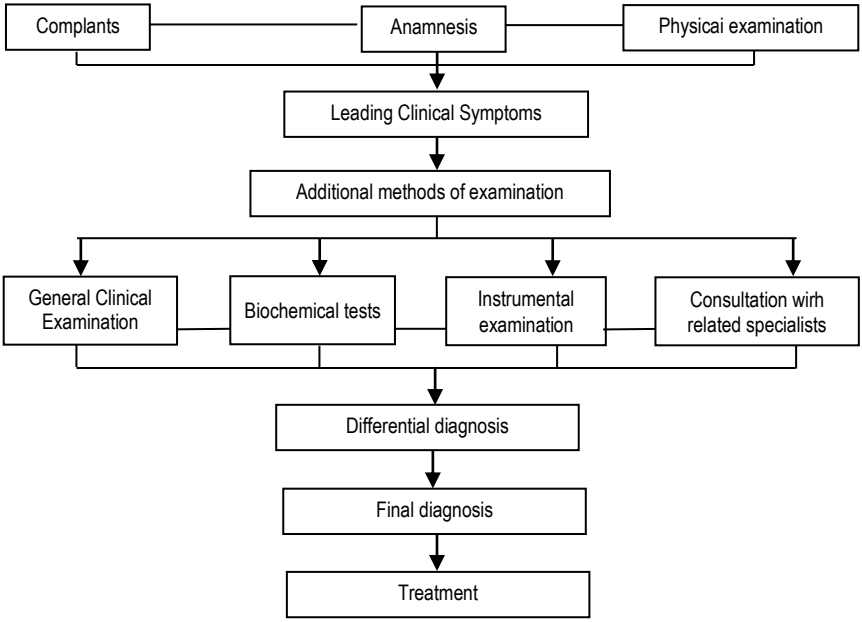
New criteria for left ventricular hypertrophy in children with hypertension differ somewhat from previous ones. The criteria for heart damage in hypertension are now as follows:

- Left ventricular hypertrophy is defined as LVM > 51 g/m² or LVM > 115 g/body surface area for boys and LVM > 95 g/body surface area for girls;
- Relative LVM wall thickness > 0.42 cm indicates concentric geometry; LVM wall thickness > 1.4 cm is pathological;
- Ejection fraction, LV < 53 % is considered reduced.
- Kidney ultrasound;
- Ophthalmoscopy;
- Home or ambulatory 24-hour blood pressure monitoring;
- Ultrasound of the carotid arteries;

If indicated:

- CT, MRI of the brain, abdominal cavity (if indicated, with contrast enhancement);
- Urine analysis by the Nechiporenko method;
- Coagulogram (fibrinogen, thrombin time, INR - if indicated);
- Determination of catecholamines (metanephrines) in urine;
- Glycemic profile, determination of glycated hemoglobin, renin, aldosterone, cortisol (in blood and daily urine), parathyroid hormone, somatotropic hormone levels.
- Ankle-brachial index;
- Dopplerography of the renal arteries;
- Polysomnography;
- Radioisotope renography/renoscintigraphy;
- Determination of pulse wave velocity.

After examining the child, a preliminary diagnosis is established, and a differential diagnosis is made between primary and secondary arterial hypertension. The algorithm for conducting differential diagnosis is presented in the diagram.



TREATMENT

The goal of treating a patient with hypertension is to achieve the maximum possible reduction in blood pressure. Therapy is adjusted for children who have not achieved target blood pressure and risk factors are addressed in primary care settings.

If the cause of hypertension is identified (secondary hypertension), etiotropic and pathogenetic therapy is performed. Treatment is provided to achieve the maximum reduction in the overall risk of developing cardiovascular complications by:

- Reducing blood pressure to less than 120/80 mmHg, with the mandatory achievement of this level if necessary;
- Modifying risk factors;
- Effectively treating concomitant clinical conditions;
- If a child is found to have elevated blood pressure, antihypertensive therapy is not prescribed;
- If first or second-degree hypertension or hypertensive disease is detected, antihypertensive therapy is prescribed in combination with non-drug therapy;
- Treatment is started with one medication to minimize complications. In the absence of an effect, a combination of several medications is used, taking into account the main pathogenetic mechanism of hypertension. Effectiveness is assessed 8–12 weeks after starting treatment.

- The need for prescribing medication antihypertensive therapy is regulated by the data presented in *Table 5*, according to which the indications for prescribing medication therapy are determined according to the degree of hypertension.
- Pharmacological treatment of hypertension in children and adolescents should be started with the prescription of one of the following drugs: an angiotensin-converting enzyme (ACE) inhibitor, an angiotensin receptor blocker, a long-acting calcium channel blocker, or a thiazide diuretic. Beta-blockers are not recommended as initial therapy in children.

Antihypertensive Drugs Recommended for Use in Children

Drug	*Age*	*Initial Dose*	*Maximum Dose*	*Frequency of Administ-ration*	*Form of Release*
Benazepril	*≥ 6 years*	*0,2 mg/kg/day (up to 10 mg/day)*	*0,6 mg/kg/day (up to 40 mg/day)*	*1 time per day*	*Tablets: 5, 10, 20, 40 mg Powder for solution*
Captopril	*Newborn Infants*	*0,05 mg/kg/day*	*6 mg/kg/day*	*3 times a day (1–4 times)*	*Tablets: 12,5, 25, 50, 100 mg Powder for solution*
		0,5 mg/kg/day	*6 mg/kg/day*		
Enalapril	*≥ 1 year*	*0,08 mg/kg/day (up to 5 mg/day)*	*0,6 mg/kg/day (up to 40 mg/day)*	*1–2 times per day*	*Tablets: 2,5, 5, 10, 20 mg*
Fasinopril	*≥ 2 years*	*< 50 кg : 0,1 mg/kg/day (up to 5 mg/day > 50 кg: mg/day*	*40 mg/day*	*1 time per day*	*Tablets: 10, 20, 40 mg*
Lisinopril	*≥ 6 years*	*0,07 mg/kg/day (up to 5 mg/day)*	*0,6 mg/kg/day (up to 40 mg/day)*	*1 time per day*	*Tablets.: 2,5, 5, 10, 20, 30, 40 mg Solution*
Candesartar	*1–5 years*	*0,02 mg/kg/day (up to 4 mg/day)*	*0,4 mg/kg/day (up to 16 mg/day)*	*1–2 times per day*	*Tablets: 4, 8, 16, 32 mg Powder for solution*
	≥ 6 years	*< 50 кg: 4 mg/day ≥ 50 кg: 8 mg/day*	*68 mg/kg/day (up to 40 mg/day)*		
Irbesartan	*6–12 years*	*< 1.4 m^2 BSA: 75 mg/day ≥ 1.4 m^2 BSA: 150 mg/day*	*300 mg/day*	*1 time per day*	*Tablets: 75, 150, 300 mg*
	≥ 13 years	*0.7 mg/kg/day (up to 150 mg/day)*	*1.4 mg/kg/day (up to 300 mg/day)*		*Powder for solution*
Losartan	*≥ 6 years*	*< 35 kg: 10 mg/day ≥ 35 kg: 25 mg/day*	*50 mg*	*1 time per day*	*Tablets: 25, 50, 100 mg*
Olmesartan	*≥ 6 years*	*< 35 kg: 10 mg/day ≥ 35 kg: 20 mg/day*	*20 mg/day*	*1 time per day*	*Tablets: 5, 20, 40 mg*
Valsartan	*≥ 6 years*	*1,3 mg/kg/day (up to 40 mg/day))*	*2,7 mg/kg/day (up to 160 mg)*	*1 time per day*	*Tablets: 40, 80, 160, 320 mg Powder for solution*
Chlorhalidone	*Children*	*0,3 mg/kg/day (30 mg)*	*2 mg/kg/day*	*1 time per day*	*Tablets: 25, 50, 100 mg*
Chlorthiazide	*Children*	*10 mg/kg/day (up to 375 mg/day)*	*20 mg/kg/day*	*1–2 times per day*	*Tablets: 250, 500 Suspension: 250 mg/ml*
Hydrochloro-thiazide	*Children*	*1 mg/kg/day (up to 375 mg/day)*	*2 mg/kg/day*	*1–2 times per day*	*Tablets: 12,5, 25, 50 mg*
Amlodipine	*1–5 years.*	*0,1 mg/kg/day (up to 5 mg/day)*	*0,6 mg/kg/day*	*1 time per day*	*Tablets: 2,5, 5, 10 mg Powder for solution*
	≥ 6 p.	*2,5 mg*	*10 mg*		
Felodipine	*≥ 6 years*	*2,5 mg*	*10 mg*	*1 time per day*	*Tablets: sustained release 2,5, 5, 10 mg*
Isradipine	*Children*	*0,05–0,1 mg/kg/day*	*0,6 mg/kg (up to 10 mg/day)*	*1–3 times per day*	*Capsules:2.5, 5 mg Tablets: sustained release :5, 10 mg*
Nifedipine SR	*Children*	*0,2–0,5 mg/kg/day*	*3 mg/kg (up to 120 mg/day)*	*1–2 times per day*	*Tablets: sustained release 30, 60, 90 mg*

NON-MEDICinal TREATMENT

Non-medicinal treatment primarily involves lifestyle modifications:

1. **Dietary recommendations** (DASH diet; Dietary Approaches to Stop Hypertension – a dietary approach to treating hypertension) include a diet rich in fruits and vegetables, low-fat dairy products, whole grains, and legumes, with limited sugar and sodium intake (less than 2300 mg per day).

2. **Stress reduction measures** are recommended for patients with hypertension, including meditation and breathing exercises.

3. **Adequate physical activity** – children and their parents should monitor their screen time, including television and computer games (no more than 2 hours per day). Physical activity should consist of at least 40 minutes of moderate to vigorous intensity exercise at least 3–5 days per week. Studies have shown that following these recommendations can lower blood pressure by 6.6 mm Hg.

4. **Participation in competitive sports** should be limited to those with Stage 2 hypertension.

Test Questions

1. A 15-year-old boy has periodic headaches, palpitations, irritability, and nausea when traveling on transport of 3 months duration. Within this period, three episodes of elevated blood pressure up to 170/100 mm Hg were recorded, accompanied by the appearance of "flies" before his eyes, tachycardia, tremor, and a feeling of fear. The episode ended with significant urination. Which of the following is the most likely diagnosis.

A. Arterial hypertension with the development of a sympathoadrenal crisis.
B. Symptomatic arterial hypertension.
C. Pheochromocytoma.
D. Vegetative dysfunction.
E. Hypothalamic syndrome.

2. A 15-year-old boy has increased appetite, rapid fatigability, increased sweating, headaches, and shortness of breath with minor physical exertion. The boy is overweight, his skin is pale pink, and subcutaneous fat is excessively and evenly distributed. The skinfold thickness on the abdomen is 6 cm, heart sounds are somewhat weakened, HR is 74 per minute, blood pressure is 130/70 mm Hg. Which of the following is the most likely diagnosis.

A. Obesity.
B. Primary arterial hypertension.
C. Pheochromocytoma.
D. Symptomatic arterial hypertension.
E. Hypothalamic syndrome.

3. A 16-year-old girl was brought to cardiology department with elevated blood pressure revealed during a routine examination at school. Which of the following examination methods is the most informative for making a diagnosis?

A. ECG.
B. EchoCG.
C. Bicycle ergometry.
D. ABPM (Ambulatory Blood Pressure Monitoring).
E. Phonocardiography.

4. A 10-year-old student has frequent abdominal pain, headaches after school and with weather changes. Sometimes during the day, the temperature rises to 37.6 (does not fall after taking aspirin), which spontaneously normalizes at night. The child gets tired quickly. On examination he is pale, his BP is 115/70 mm Hg, the pulse is labile. There is unstable anisocoria, hyperhidrosis of the hands and feet, persistent red diffuse dermographism. The gastrointestinal tract and blood tests are normal. Which of the following is the most likely diagnosis?

A. Pheochromocytoma.
B. Primary arterial hypertension.
C. Hypothalamic syndrome.
D. Secondary arterial hypertension.
E. High blood pressure, autonomic-vascular dystonia.

5. A 15-year-old girl complains of worsening condition due to the appearance of sweating, irritability, rapid fatigability, and weight loss. On examination, she has tachycardia. The girl is referred to the hospital with a diagnosis of acute rheumatic fever. On admission, her condition is moderately severe. There is increased sweating. The thyroid gland is evenly enlarged (Grade I). Exophthalmos is moderately pronounced. The borders of relative cardiac dullness are normal. Heart sounds are accentuated, there is systolic murmur at the apex and at the V point. Her pulse is 120 beats per minute, labile; blood pressure is 150/80 mm Hg. There is a sharply pronounced tremor of the fingers of outstretched hands. There are no deviations in other organs and systems. Which of the following is the most likely diagnosis?

A. Primary arterial hypertension.
B. Symptomatic arterial hypertension. Hyperthyroidism.
C. Pheochromocytoma.
D. Adrenogenital syndrome.
E. Hypothalamic syndrome.

6. A 17-year-old girl, after a nervous stress, has shortness of breath, tremor, a feeling of fear and a "lump" in her throat, and stabbing and aching pain in the heart area. On examination, there are red spots on her face and neck, vesicular breathing, respiratory rate 26/min. The heart borders are normal, the sounds are clear and rhythmic. Heart rate is 120/min, blood pressure is 155/80 mm Hg. The ambulance doctor believes that this is a somatoform disorder. Which of the following is the most likely diagnosis?

A. Development of a sympathoadrenal crisis.
B. Primary arterial hypertension.
C. Pheochromocytoma.
D. Vegetative-vascular dystonia.
E. Hypothalamic syndrome.

7. A 14-year-old boy has been under observation for 3 years for elevated blood pressure up to 170/100 mm Hg. Treatment with antihypertensive drugs is ineffective. ABPM: stable arterial hypertension. Doppler of renal vessels shows partial visualization of the renal arteries, left. Which of the following is the preliminary diagnosis?

A. Pheochromocytoma.
B. Adrenogenital syndrome.
C. Renovascular hypertension.
D. Primary arterial hypertension.
E. Hypothalamic syndrome.

Answers:
1 – *B*; **2** – *A*; **3** – *D*– **4** – *B*; **5** – *B*; **6** – *A*; **7** – *C*.

Situational Task

Task 1. A 16-year-old girl, L., is admitted to the children's hospital with headache, nosebleeds, weakness and fatigue, and elevated blood pressure which appeared after a stressful situation occurred over the past two weeks. After examination by a pediatrician, it was recommended to measure blood pressure for a week. Her family medical history indicates a predisposition to hypertension in her grandmother and grandfather, diabetes and obesity in her father. On examination, the child's condition is moderately severe, T – 36.4 °C, respiratory rate 20/min., HR 102/min, BP 140/90 mm Hg. The girl is emotionally labile, complains of discomfort during emotional and physical exertion. The girl eats "unhealthy" food and has a reduced activity level. The skin is pale and clear, with stretch marks on the skin. Subcutaneous fat is excessively developed on the torso. Physical development exceeds age norms in weight (97th percentile). On percussion there is a shift in the left border of relative cardiac dullness by 1.5 cm from the midclavicular line. On auscultation, heart sounds are accentuated over the aortic projection, tachycardia. Attention is drawn to the lability of cardiovascular parameters during examination: BP during repeated measurements 125/80, HR 78 per minute. No abnormalities are detected in the other organs and systems. Make a preliminary diagnosis for the child. Prescribe an examination plan and management tactics.

Answer: Arterial hypertension, labile course. Overweight.

It is necessary to exclude secondary causes of hypertension in the examination. The child requires a standard laboratory examination with a study of lipid profile indicators, uric acid, creatinine, sugar levels, instrumental examination - ECG, ultrasound of the heart and blood vessels, thyroid gland, kidneys and adrenal glands. The child should be examined by an ophthalmologist and neurologist. Management tactics consist of the need to control blood pressure levels, adherence to lifestyle modifications: DASH diet, stress reduction, adequate physical activity of at least 40 minutes per day, weight loss.

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Навчальне видання

ТАКТИКА ВЕДЕННЯ ТА ЛІКУВАННЯ АРТЕРІАЛЬНОЇ ГІПЕРТЕНЗІЇ У ДІТЕЙ

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Упорядники Гончарь Маргарита Олександрівна
Уриваєва Марина Кузьмівна
Сенаторова Анна Сергіївна

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Редакційно-видавничий відділ
ХНМУ, пр. Науки, 4, м. Харків, 61022
izdatknmurio@gmail.com, vid.redact@knmu.edu.ua

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