Ministry of Health of the Republic of Belarus
Educational Institution
“Gomel State Medical University”

Department of Pathological Anatomy

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METHODICAL GUIDELINES

for conducting a practical class
in the academic discipline “Pathological Anatomy”
for students
of the 3rd year, Faculty of International Students (instruction in English),
enrolled in the specialty
7-07-0911-01 “General Medicine”

Topic: “Cardiovascular system diseases. Atherosclerosis. Ischemic heart disease. Arterial hypertension. Cerebrovascular diseases”

Duration: 3 hours

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EDUCATIONAL AND INSTRUCTIONAL GOALS, OBJECTIVES, AND MOTIVATION FOR MASTERING THE TOPIC

Educational Goal:

- To study the clinical-morphological manifestations and morphogenesis of atherosclerosis. To indicate the high prevalence of the disease. To analyze the stages of atherosclerosis development (prelipid stage, lipoidosis, liposclerosis, atheromatosis, complicated lesions, calcification) and their relationship to disorders of neurohumoral regulation of vascular tone associated with age. To note the significance of functional-mechanical factors in the localization and rate of development of atherosclerotic plaques.
- To characterize the clinical-anatomical forms of atherosclerosis with predominant involvement of the arteries of the heart, brain, lower extremities, kidneys, intestines, and aorta.
- To draw attention to the differences in changes occurring in organs during the chronic course of atherosclerosis (hypoxia, dystrophy, atrophy, sclerosis) versus acute circulatory disorders caused by spasm or thrombosis (ischemia, necrosis, infarction).
- To analyze the complications of atherosclerosis and the causes of death in patients with clinical-anatomical forms of atherosclerosis (softening and hemorrhage in brain tissue, intestinal gangrene, gangrene of the lower extremities, aortic aneurysm, nephrosclerosis).
- To provide a modern understanding of ischemic heart disease (IHD) and its forms (acute – myocardial infarction, acute cardiac aneurysm, sudden coronary death, acute focal ischemic dystrophy of the myocardium; chronic – cardiosclerosis, chronic cardiac aneurysm); morphological changes and outcomes.
- To study the clinical-morphological manifestations of hypertension and its three stages: functional, morphological changes of vessels, and secondary changes in organs. To analyze the nature and sequence of changes in arterioles and small arteries (spasm, hypertrophy of the muscular layer, varying degrees of permeability disturbance, plasmorrahagia, fibrinoid necrosis, and as an outcome of these processes, arteriolohyalinosis).
- To study changes in medium-sized arteries (hyperelastosis, elastofibrosis), large arteries, and the aorta (atherosclerosis).
- To emphasize the significance of functional disorders in stage 1 of the disease and to focus attention on the earliest morphological sign of hypertension (left ventricular myocardial hypertrophy). To discuss possible variants of clinical-anatomical forms of the disease depending on predominant involvement of the cerebral, cardiac, and renal vessels. To analyze the causes of death in patients suffering from hypertension (cerebral hemorrhage, acute and chronic heart failure, renal failure). The concept of a hypertensive crisis and its morphological manifestations.

Instructional Goal:

- Within the framework of the educational process for this academic discipline, the student must acquire not only theoretical knowledge, practical skills and abilities in the specialty but also develop their personal potential. They should cultivate qualities of responsibility and patriotism, be prepared to actively participate in the economic, socio-cultural, and public life of the country, recognize the social significance of their future professional activity, understand the norms of medical ethics and deontology, and learn to observe academic and labor discipline. In the course of studying the educational material, students should realize the importance of maintaining a healthy lifestyle and, as an example in the future, when performing professional duties, set an example for those around them and their patients.

Objectives: Upon completion of the practical session, the student must:

***Know*:**

- The definition of atherosclerosis;
- The morphology of the stages and various clinical-anatomical forms of atherosclerosis;
- Modern theories of the development of atherosclerosis and name the most significant factors in its development;
- The complications and outcomes of various clinical-anatomical forms of atherosclerosis;
- The definition of hypertension;
- The morphology of the stages of hypertension, mechanisms of development, and factors contributing to the development of the disease;
- The various forms of hypertension based on clinical-morphological features;
- The significance of complications and outcomes of various clinical-morphological forms of hypertension;
- Symptomatic hypertension depending on its cause;
- The definition of ischemic heart disease (IHD) and identify the main etiopathogenetic factors in its development;
- The various forms of IHD and diagnose them based on macroscopic and microscopic characteristics;
- The complications and causes of death in various forms of IHD.

Be able to:

- Identify major general pathological processes and diseases using histological specimens under light microscopy;
- Diagnose pathological processes and diseases based on the description of macroscopic and microscopic changes in organs and tissues of the body.

***Master*:**

- Basic techniques for working with a microscope;
- Skills in clinical-anatomical analysis;
- The fundamentals of synthetic generalization of morphological diagnostic signs of diseases and their correct interpretation in cause-and-effect relationships.

Motivation for Mastering the Topic:

Mastery of the materials of this topic is a necessary prerequisite for understanding the patterns of morphological reactions and their clinical manifestations in the development of atherosclerosis, ischemic heart disease, and hypertension, which occupy leading roles in the structure of morbidity. The incidence of atherosclerosis worldwide has increased significantly over the past 50 years and continues to rise in all European countries. A trend toward its reduction over the past decade has been noted only in the United States. The disease usually manifests in the second half of life. Complications of atherosclerosis are among the most common causes of disability and mortality in most countries of the world. Patients with manifestations of atherosclerosis are hospitalized in practically every medical specialty. The significant reduction in fatal complications on the American continent is the result of joint efforts not only of cardiologists and pharmacotherapists but also of epidemiologists. Thus, knowledge of this pathology is also necessary for physicians in preventive medicine. Knowledge of the morphological substrate of the disease, especially the early manifestations of atherosclerosis, will allow the specialist to provide not only competent, pathogenetically based treatment but also to determine the nature of preventive measures.

Hypertension (high blood pressure) is the most common cause of high morbidity and mortality worldwide. Most cases of hypertension are classified as "primary," but it is necessary to remember the possibility of not identifying the cause due to insufficient examination of the patient. It is generally accepted that hypertension, like atherosclerosis, is a disease of urbanization and is widespread in economically developed countries experiencing increasing tension in the psycho-emotional sphere. Hypertension is called the "disease of unexpressed emotions." An epidemiological study on the African continent, as well as in some areas located in the eastern Pacific, found unusually low average blood pressure among residents. However, in East and North Africa, a high incidence of hypertension with a tendency to progress has been recorded. Assistance to patients with hypertension and secondary hypertension is provided by specialists of various profiles: therapists, nephrologists, cardiologists, neurologists, neurosurgeons, and others. Knowledge of the morphological substrate of primary and secondary hypertension is necessary for specialists in clinical and preventive medicine. For better understanding of this topic, knowledge of the following general pathological processes is required: all types of alterations, circulatory and lymphatic disorders, and compensatory-adaptive processes.

Ischemic heart disease is coronary heart disease. It was identified as an "independent disease" by the World Health Organization in 1965 due to its great social significance. Ischemic heart disease is currently widespread throughout the world, especially in economically developed countries. The danger of ischemic heart disease lies in sudden death. It accounts for approximately 2/3 of deaths from cardiovascular diseases. The disease most often affects men aged 40–65 years.

QUESTIONS

1. Atherosclerosis. Definition. Etiology. Pathogenesis. Classification. Morphology. Microscopic stages of atherosclerosis. Clinical forms of atherosclerosis. Complications and outcomes.
2. Arterial hypertension. Definition. Etiology. Pathogenesis. Classification. Morphology. Complications and outcomes.
3. Ischemic heart disease. Definition. Etiology. Pathogenesis. Classification. Morphology. Complications and outcomes. Morphology of chronic heart failure.
4. Myocardial infarction. Definition. Etiology. Pathogenesis. Classification. Morphology. Complications and outcomes.
5. Cerebrovascular diseases. Definition. Etiology. Pathogenesis. Classification. Morphology. Complications and outcomes.

COURSE OF THE SESSION

Atherosclerosis is a chronic disease resulting from a violation of fat and protein metabolism, characterized by damage of the elastic and muscular arteries in the form of focal deposits in the intima of lipids and proteins, as well as reactive proliferation of connective tissue. The main morphological expression of atherosclerosis is a plaque that narrows the lumen of the artery, resulting in insufficient blood supply to the organs.

Etiology. Atherosclerosis is a polyetiological disease associated with the influence of various exogenous and endogenous factors, of which hereditary, environmental and nutritional factors are of primary importance.

Factors risks:

I. Major constitutional risk factors: age, sex, genetic factors.

II. Major acquired risk factors: hyperlipidemia, hypertension, diabetes mellitus, smoking.

III. Minor risk factors.

Atherosclerosis

Major constitutional risk factors

1. **Age**. Atherosclerosis is an age-related disease. Though early lesions of atherosclerosis may be present in childhood, clinically significant lesions are found with increasing age. Fully-developed atheromatous plaques usually appear in the 4th decade and beyond. Evidence in support comes from the high death rate from IHD in this age group.

2. **Sex**. The incidence and severity of atherosclerosis are more in men than in women. The prevalence of atherosclerotic IHD is about three times higher in men in the 4th decade than in women and the difference slowly declines with age but remains higher at all ages in men. The lower incidence of IHD in women, especially in premenopausal age, is probably due to high levels of estrogen and high-density lipoproteins, both of which have antiatherogenic influence.

3. **Genetic factors**. Genetic factors play a significant role in atherogenesis. Hereditary genetic derangements of lipoprotein metabolism predispose the individual to high blood lipid level and familial hypercholesterolemia.

4. **Familial and racial factors**: The familial predisposition to atherosclerosis may be related to other risk factors like diabetes, hypertension and hyper-lipoproteinemia. Racial differences too exist; Blacks have generally less severe atherosclerosis than Whites.

Major acquired risk factors

1. **Hyperlipidemia** . The main lipids in blood are cholesterol (normal 140-240 mg/dl) and triglycerides (below 160 mg/dl). An elevation of serum cholesterol levels above 260 mg/dl in men and women between 30 and 50 years of age has three times higher risk of developing IHD as compared with people with serum cholesterol levels within normal limits.

The concentration of cholesterol in the serum reflects the concentrations of different lipoproteins in the serum.

The major fractions of lipoproteins and their varying effects on atherosclerosis and IHD are as under:

1) Low-density lipoprotein (**LDL**) is richest in cholesterol and has the maximum association with atherosclerosis.

2) Very-low-density lipoprotein (**VLDL**) carries much of the triglycerides and has less marked effect than LDL.

3) High-density lipoprotein (**HDL**) is protective against atherosclerosis.

2.**Hypertension**. Hypertension is the other major risk factor in the development of atherosclerotic IHD and cerebrovascular disease. It acts probably by mechanical injury to the arterial wall due to increased pressure. A systolic pressure of over 160 mmHg or a diastolic pressure of over 95 mmHg is associated with five times higher risk of developing IHD than in people with blood pressure within normal range (140/90 mmHg or less).

3. **Smoking**. The extent and severity of atherosclerosis are much greater in smokers than in non-smokers. Cigarette smoking is associated with higher risk of atherosclerotic IHD and sudden cardiac death. Men who smoke a pack of cigarettes a day are 3-5 times more likely to die of IHD than nonsmokers. The increased risk and severity of atherosclerosis in smokers is due to reduced level of HDL and accumulation of carbon monoxide in the blood that produces carboxy- hemoglobin and eventually hypoxia in the arterial wall favoring atherosclerosis.

4. **Diabetes mellitus**. Clinical manifestations of atherosclerosis are far more common and develop at an early age in people with both insulin dependent and non-insulin dependent diabetes mellitus. The risk of developing IHD is doubled, the tendency to develop cerebrovascular disease is high, and the frequency to develop gangrene of foot is about 100 times increased.

Minor risk factors

1) Higher incidence of atherosclerosis in developed countries and low prevalence in underdeveloped countries, suggests the role of **environmental influences**

2) **Obesity**, if the person is overweight by 20% or more

3) Use of **oral contraceptives** by women has been shown to have increased risk of developing myocardial infarction or stroke

4) **Lack of exercise** is associated with the risk of developing atherosclerosis and its complications

5) **Moderate consumption of alcohol** appears to have slightly beneficial effect by **raising the level of HDL** cholesterol.

6) The role of **viruses** in atherogenesis has been implicated recently. In chickens, avian herpesvirus, besides producing lymphoid tumour, also produces intimal cell proliferation of muscular arteries and alters the metabolism of lipid and cholesterol in these cells. Viral infection would explain intimal cell proliferation and monoclonal cell proliferation in atheromatous lesion.

Pathogenesis

Currently, the pathogenesis of atherosclerosis is explained on the basis of the following **two theories**:

1) **Response-to-injury hypothesis**, first described in 1973, and modified in 1986 and 1993 by Ross.

2) **Monoclonal theory**, postulated by Benditt and Moss in 1973.

Response-to-injury hypothesis

The original response to injury theory was first described in **1973** according to which the initial event in atherogenesis was considered to be **endothelial injury** followed by **smooth muscle cell proliferation** so that the early lesions, according to this theory, consist of smooth muscle cells mainly.

The **modified** response-to-injury hypothesis subsequently described in **1993** implicates **lipoprotein entry** into the intima as the initial event followed by lipid accumulation in the **macrophages** (foam cells) which, according to modified theory, are believed to be the dominant cells in early lesions.

Monoclonal hypothesis

This hypothesis is based on the postulate that **proliferation of smooth muscle cells** is the **primary event** and that this proliferation is monoclonal in origin similar to cellular proliferation in neoplasms (eg in uterine leiomyoma).

The evidence cited in support of monoclonal hypothesis is the observation on proliferated smooth muscle cells in atheromatous plaques which have only one of the two forms of **glucose-6-phosphate dehydrogenase** (G6PD) isoenzymes, suggesting **monoclonality** in origin.

The monoclonal proliferation of smooth muscle cells in atherosclerosis may be initiated by **mutation caused by exogenous chemicals** (eg cigarette smoke), **endogenous metabolites** (eg lipoproteins) and some **viruses** (eg Marek's disease virus in chickens, herpesvirus).

Stages of the pathogenesis

1. The development of **atherogenic dyslipoproteinemia**, accompanied by the appearance of modified lipoproteins, which are intensively captured by endothelial cells and transferred to the subendothelial space.

2. **Damage to the endothelium** by modified lipoproteins or other factors (viruses, immune complexes, bacterial toxins, etc.).

3. **Increased vascular permeability** and insudation of plasma components, including lipoproteins into the intima.

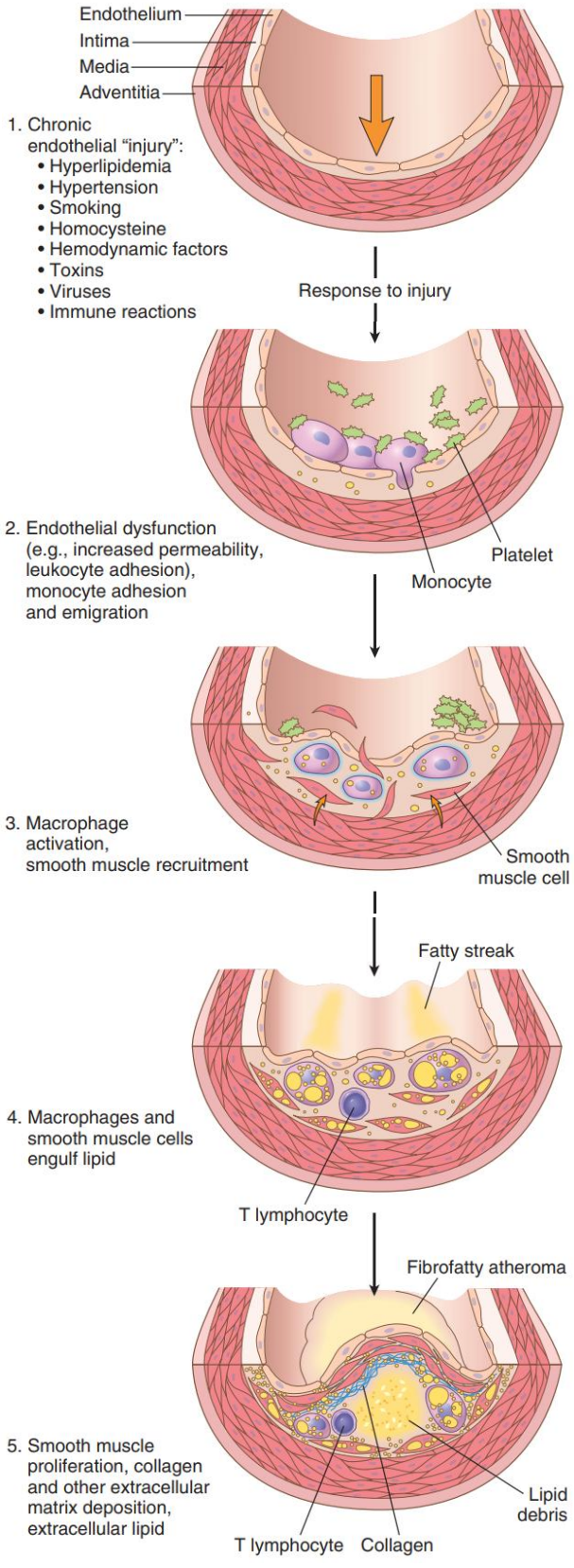
4. **Adhesion of platelets and monocytes to the endothelium**, migration of monocytes to the intima, their transformation into activated macrophages and the production of numerous cytokines (interleukin-1, platelet growth factor, tumor necrosis factor), which enhance cell migration and proliferation.

5. **Migration** into the intima and proliferation of **smooth muscle cells** (SMCs) under the influence of platelet growth factor secreted by macrophages, endothelium and SMCs themselves, which adopt a synthetic phenotype (usually the contractile phenotype predominates), synthesize collagen and elastic fibers, proteoglycans , i.e. form the basis of atherosclerotic plaque.

6. **Further modification of lipoproteins** in the intima, the formation of **complexes with proteoglycans**, their capture by macrophages, which, when the utilization and excretion systems (primarily lysosomes) are depleted, are filled with lipids and turn into foamy, or xanthomic cells.

7. Subsequent changes in the plaque are associated with the **formation of new capillaries** in it under the influence of growth factors, the involvement of other cellular elements (T-lymphocytes and B-lymphocytes, fibroblasts), necrosis of the central parts of the plaque, sclerosis, hyalinosis, and calcification.

Pathogenesis of atherosclerosis



Morphological changes

1. **Fat streaks & stripes** - areas of yellow or yellow-gray color (spots), which sometimes merge and form stripes, but do not rise above the surface of the intima.

2. **Fibrofatty plaques** - dense oval or rounded white or yellowish-white formations that rise above the surface of the intima, often merging and giving the intima a bumpy appearance, followed by narrowing of the lumen of the artery.

3. **Complicated lesions**.

- fibrous plaques with ulceration (atheromatous ulcer)
- hemorrhages in the thickness of the plaque (intramural hematoma)
- thrombosis at the site of ulceration of the plaque

Complicated lesions are associated with the development of a heart attack (with acute thrombosis), embolism with both thrombotic and atheromatous masses, the formation of an aneurysm of the vessel at the site of its ulceration, as well as arterial bleeding when the vessel wall is corroded by an atheromatous ulcer.

4. **Calcification (atherocalcinosis)** - the final phase of atherosclerosis, which is characterized by the deposition of calcium salts in fibrous plaques.

Morphological changes

These changes correlate with the stages of atherosclerosis morphogenesis:

1. prelipid
2. lipoidosis
3. liposclerosis
4. atheromatosis
5. ulceration
6. atherocalcinosis

Complications of atherosclerosis

Regardless of the localization of atherosclerotic changes, two groups of complications are distinguished: chronic and acute.

Chronic complications. Atherosclerotic plaque, protruding into the lumen of the vessel, leads to narrowing (stenosis) of its lumen. Since the formation of plaque in the vessels is a slow process, chronic ischemia occurs in the area of blood supply to this vessel. Chronic vascular insufficiency is accompanied by hypoxia, dystrophic and atrophic changes in the organ and proliferation of connective tissue. Slow occlusion of blood vessels leads to small-focal sclerosis in organs.

Acute complications. They are caused by the occurrence of blood clots, emboli, vasospasm. Acute vascular occlusion leads to the development of organ infarctions (for example, myocardial infarction, strokes, etc.).

Clinical and morphological forms

Depending on the predominant localization of atherosclerotic changes in the vessels, complications and outcomes to which it leads, the following clinical and anatomical forms are distinguished:

1. atherosclerosis of the aorta;

2. atherosclerosis of the coronary arteries (ischemic heart disease);
3. atherosclerosis of the arteries of the brain (cerebrovascular diseases);
4. atherosclerosis of the arteries of the kidneys (renal form);
5. atherosclerosis of the arteries of the intestine (intestinal form);
6. atherosclerosis of the arteries of the lower extremities.

Aortic atherosclerosis

Aortic atherosclerosis is the **most common form** of atherosclerosis. Atherosclerotic changes are most pronounced in the abdominal region and are usually characterized by atheromatosis, ulceration, and atherocalcinosis .

As a result of thrombosis, thromboembolism and embolism with atheromatous masses in aortic atherosclerosis, infarctions (eg kidney) and gangrene (eg intestines, lower extremities) are often observed.

With atherosclerosis, **aneurysms** often develop in the aorta. The formation of an aneurysm is dangerous by its rupture and bleeding. A long-standing aortic aneurysm leads to atrophy of surrounding tissues (eg sternum, vertebral bodies).

Atherosclerosis

Atherosclerosis of the coronary arteries of the heart leads to ischemic heart disease.

Atherosclerosis of the arteries of the brain is the basis of cerebrovascular diseases. Prolonged ischemia of the brain on the basis of stenosing atherosclerosis of the cerebral arteries leads to dystrophy and atrophy of the cerebral cortex , the development of atherosclerotic dementia.

Atherosclerosis of the renal arteries

In **atherosclerosis of the renal arteries**, a narrowing of the lumen by a plaque is usually observed at the site of a branch of the main trunk or its division into branches of the first and second order. More often the process is unilateral, less often it is bilateral. In the kidneys, either wedge-shaped areas of parenchyma atrophy with stromal collapse and replacement of these areas with connective tissue, or infarcts with their subsequent organization and the formation of retracted scars, develop. There is a large-tuberous atherosclerotic wrinkled kidney (atherosclerotic nephrosclerosis), the function of which suffers little, since most of the parenchyma remains intact. As a result of ischemia of the renal tissue with stenosing atherosclerosis of the renal arteries, in some cases, symptomatic (renal) hypertension develops.

Atherosclerosis

Atherosclerosis of the **intestinal arteries**, complicated by thrombosis, leads to **gangrene of the intestine**, followed by the development of **peritonitis**. The superior mesenteric artery is more commonly affected.

With **atherosclerosis of the arteries of the extremities** , the femoral arteries are more often affected. The process is asymptomatic for a long time due to the development of collaterals. However, with increasing insufficiency of collaterals,

atrophic changes in muscles develop, coldness of the limb, characteristic pains appear when walking - intermittent claudication.

If atherosclerosis is complicated by thrombosis, gangrene of the limb develops - atherosclerotic gangrene.

Arterial hypertension

Arterial hypertension is a chronic disease, the main clinical manifestation of which is a **long-term persistent increase in blood pressure** (systolic - more than 140 mm Hg , diastolic - more than 90 mm hg).

Hypertension by **etiology** can be classified accordingly:

1. Primary or **essential hypertension** in which the cause of increase in blood pressure is unknown. Essential hypertension constitutes about 90-95% of patients of hypertension.

2. **Secondary hypertension**, in which the increase in blood pressure is caused by diseases of the kidneys, endocrines or some other organs. Secondary hypertension comprises 5-10% cases of hypertension.

Arterial hypertension

According to the **clinical course**, both essential and secondary hypertension may be **benign** or **malignant**.

1) **Benign hypertension** is moderate elevation of blood pressure and the rise is slow over the years. About 90-95% of patients of hypertension have benign hypertension.

2) **Malignant hypertension** is marked and rapid increase of blood pressure to 200/140 mm Hg or more and the patients have papilledema, retinal hemorrhages and hypertensive encephalopathy.

Less than 5% of hypertensive patients develop malignant hypertension and life expectancy after diagnosis in these patients is generally less than 2 years if not treated effectively.

Etiology and Pathogenesis of AH

The etiology and pathogenesis of **secondary hypertension** that comprises less than 10% of cases has been better understood, whereas the mechanism of **essential hypertension** that constitutes about 90% of cases remains largely obscure.

In general, normal blood pressure is regulated by **2 hemodynamic forces** – **cardiac output** and total **peripheral vascular resistance**.

Factors which alter these two factors result in hypertension.

The role of kidney in hypertension, particularly in secondary hypertension, by elaboration of renin and subsequent formation of angiotensin II, is well established (renin-angiotensin system).

Essential hypertension

1. **Genetic factors**.

The role of heredity in the etiology of essential hypertension has long been suspected.

The evidences in support are the familial aggregation, occurrence of hypertension in twins, epidemiologic data, experimental animal studies and identification of hypertension susceptibility gene (angiotensinogen gene).

2. **Racial and environmental factors**.

Surveys in the US have revealed higher incidence of essential hypertension in blacks than in whites.

A number of environmental factors have been implicated in the development of hypertension including salt intake, obesity, skilled occupation, higher living standards and patients in high stress.

3. **Risk factors modifying the course of essential hypertension**. There is sufficient evidence to show that the course of essential hypertension that begins in middle life is modified by a number of factors:

1) **Age**. Younger the age at which hypertension is first noted but left untreated, lower the life expectancy.

2) **Sex**. Females with hypertension appear to fare better than males.

3) **Atherosclerosis**. Accelerated atherosclerosis invariably accompanies essential hypertension. This could be due to a contributory role of other independent factors like smoking, elevated serum cholesterol, glucose intolerance and obesity.

4) Other risk factors. Other factors which alter the prognosis in hypertension include: **smoking**, **excess of alcohol intake**, **diabetes mellitus**, etc.

Essential hypertension

The **pathogenetic mechanism** in essential hypertension is explained by many theories:

1. High plasma levels of **catecholamines**.

2. Increase in blood volume i.e. **arterial overfilling** (volume hypertension) and **arteriolar constriction** (vasoconstrictor hypertension).

3. **Increased cardiac output**.

4. **Low-renin essential hypertension** found in approximately 20% of patients due to altered responsiveness to renin release.

5. **High-renin essential hypertension** seen in about 15% of cases due to decreased adrenal responsiveness to angiotensin II.

Secondary hypertension

Etiological classification: renal hypertension, endocrine hypertension, hypertension associated with coarctation of aorta and neurogenic causes.

1. **Renal Hypertension**. Hypertension produced by renal diseases is called renal hypertension. Renal hypertension is subdivided into 2 groups:

1) **Renal vascular hypertension** eg in occlusion of a major renal artery, pre-eclampsia, eclampsia, polyarteritis nodosa and fibromuscular dysplasia of renal artery.

2) **Renal parenchymal hypertension** eg in various types of glomerulonephritis, pyelonephritis, interstitial nephritis, diabetic nephropathy, amyloidosis, polycystic kidney disease and renin-producing tumours.

In either case, renal hypertension can be produced by one of the 3 interrelated pathogenetic mechanisms:

a) activation of the renin-angiotensin system

b) sodium and water retention

c) release of vasodepressor materials decreased

2. **Endocrine hypertension**. A number of hormonal secretions may produce secondary hypertension. These are:

1) Adrenal gland – eg in primary aldosteronism, Cushing's syndrome, adrenal virilism and pheochromocytoma.

2) Parathyroid gland - eg hypercalcemia in hyperparathyroidism.

3) Oral contraceptives - Estrogen component in the oral contraceptives stimulates hepatic synthesis of renin substrate.

3. **Coarctation of aorta**. Coarctation of the aorta causes systolic hypertension in the upper part of the body due to constriction itself. Diastolic hypertension results from changes in circulation.

4. **Neurogenic**. Psychogenic, polyneuritis, increased intracranial pressure and section of spinal cord are all uncommon causes of secondary hypertension.

Effects of hypertension

Systemic hypertension causes major effects in **three main organs** – **heart** and its blood vessels, **nervous system**, and **kidneys**.

Benign nephrosclerosis is the term used to describe the kidney of benign phase of hypertension. Mild benign nephrosclerosis is the most common form of renal disease in persons over 60 years old but its severity increases in the presence of hypertension and diabetes mellitus.

Grossly, both the kidneys are affected equally and are reduced in size and weight, often weighing about 100 grams or less. The capsule is often adherent to the cortical surface. The surface of the kidney is finely granular and shows V-shaped areas of scarring. The cut surface shows firm kidney and narrowed cortex. Microscopically, there are primarily diffuse vascular changes which produce parenchymal changes secondarily as a result of ischemia.

Benign nephrosclerosis

The histological changes:

1) **Vascular** changes:

a) **Hyaline arteriolosclerosis** that results in homogeneous and eosinophilic thickening of the wall of small blood vessels.

b) **Intimal thickening** due to proliferation of smooth muscle cells in the intima.

2) **Parenchymal** changes: As a consequence of ischemia, there is a variable degree of **atrophy** of parenchyma.

This includes: glomerular shrinkage, deposition of collagen in Bowman's space, periglomerular fibrosis, tubular atrophy and fine interstitial fibrosis.

Malignant nephrosclerosis

Malignant nephrosclerosis is uncommon and usually occurs as a superimposed complication in 5% cases of preexisting benign essential hypertension

or in those having secondary hypertension with identifiable cause such as in chronic renal diseases.

Microscopically, most commonly the changes are superimposed on benign nephrosclerosis

1) **Vascular** changes:

a) **Necrotizing arteriolitis** develops on hyaline arteriolosclerosis. The vessel wall exhibits **fibrinoid necrosis**, a few acute inflammatory cells and small hemorrhages.

b**) Hyperplastic intimal sclerosis** or onionskin proliferation is characterized by concentric laminae of proliferated smooth muscle cells, collagen and basement membranes.

2) **Ischemic** changes: The effects of vascular narrowing on the parenchyma include tubular loss, fine interstitial fibrosis and foci of infarction necrosis.

Ischemic heart disease (IHD)

Ischemic heart disease (**IHD**) is a group of diseases caused by absolute or relative **insufficiency of coronary circulation**.

Ischemic heart disease is a **cardiac form of atherosclerosis**, manifested by ischemic myocardial dystrophy, myocardial infarction, cardiosclerosis. Coronary heart disease flows in waves, accompanied by coronary crises, i.e. episodes of acute (absolute) coronary insufficiency occurring against the background of chronic (relative insufficiency of coronary circulation).

In this regard, there are **acute and chronic forms** of IHD.

Risk Factors for Developing IHD:

1. Hypercholesterolemia
2. Smoking
3. Arterial hypertension
4. Physical inactivity
5. Obesity
6. Stress
7. Impaired glucose tolerance
8. Male gender (higher risk compared to females)
9. Advanced age
10. Other factors

Ischemic heart disease (IHD)

The main point in the **pathogenesis** is the discrepancy between the level of myocardial oxygen supply and the need for it, due to atherosclerotic changes in the coronary arteries.

The severity of ischemic myocardial damage in coronary artery disease depends not only on the prevalence and nature of coronary artery damage, but also on the level of metabolism and functional burden of the myocardium.

Causes of ischemic myocardial damage can be:

- thrombosis of the coronary arteries;

- embolism;
- prolonged spasm;
- stenosis;
- functional overstrain of the myocardium in conditions of insufficient collateral blood supply.

Ischemic myocardial damage can be **reversible** and **irreversible**.

Reversible ischemic damage develops in the first **20-30 minutes** after the onset of ischemia, and after the cessation of exposure to the factor that caused them, they completely disappear.

Irreversible ischemic changes begin with ischemia lasting more than 20-30 minutes. The first **18-24 hours** from the moment of development of ischemia, morphological changes are recorded only using electron microscopy, histochemical and luminescent research methods. Through **18-24 hours** appear micro- and macroscopic manifestations.

According to the nature of the course, the following forms of IHD are distinguished:

- **acute**;
- **chronic**.

Acute IHD is morphologically manifested by **ischemic myocardial dystrophy** and **myocardial infarction**.

Chronic IHD is morphologically manifested by **cardiosclerosis**, sometimes complicated by chronic heart **aneurysm**.

Ischemic myocardial dystrophy, or acute focal myocardial dystrophy, develops during relatively **short episodes of a coronary crisis**, when characteristic changes in the ECG occur in the absence of myocardial necrosis (there is no increase in the activity of transaminases, lactate dehydrogenase , etc.). Microscopically, dilatation of capillaries, edema of interstitial tissue, perivascular hemorrhages are found. Muscle fibers lose their transverse striation , lack glycogen, which indicates necrobiotic changes. The most common complication of ischemic myocardial dystrophy is acute heart failure.

Sudden coronary death - death occurring within the first 6 hours after the onset of acute ischemia, most likely due to **ventricular fibrillation**. In most cases, an ECG and an enzymatic blood test are not informative.

Myocardial infarction

Myocardial infarction (MI) is ischemic necrosis of the heart muscle.

MI is usually classified according to a number of criteria:

- according to the time of its occurrence
- by localization in various parts of the heart and cardiac muscle
- by prevalence (how much muscle tissue is affected)

Primary acute MI lasts for **8 weeks** from the moment of myocardial ischemia. If myocardial infarction develops **8 weeks after** the primary (acute), then it is called a **recurrent** infarction. A heart attack that develops **within 8 weeks** of the existence of a primary (acute) is referred to as **reiterative** myocardial infarction.

The topography and size of the infarct are determined not only by the degree of damage to certain branches of the coronary arteries, but also by the type of blood supply to the heart (left, right and middle types).

Myocardial infarction

Topographically distinguish:

- subendocardial infarction
- subepicardial infarction
- intramural infarction
- transmural infarction

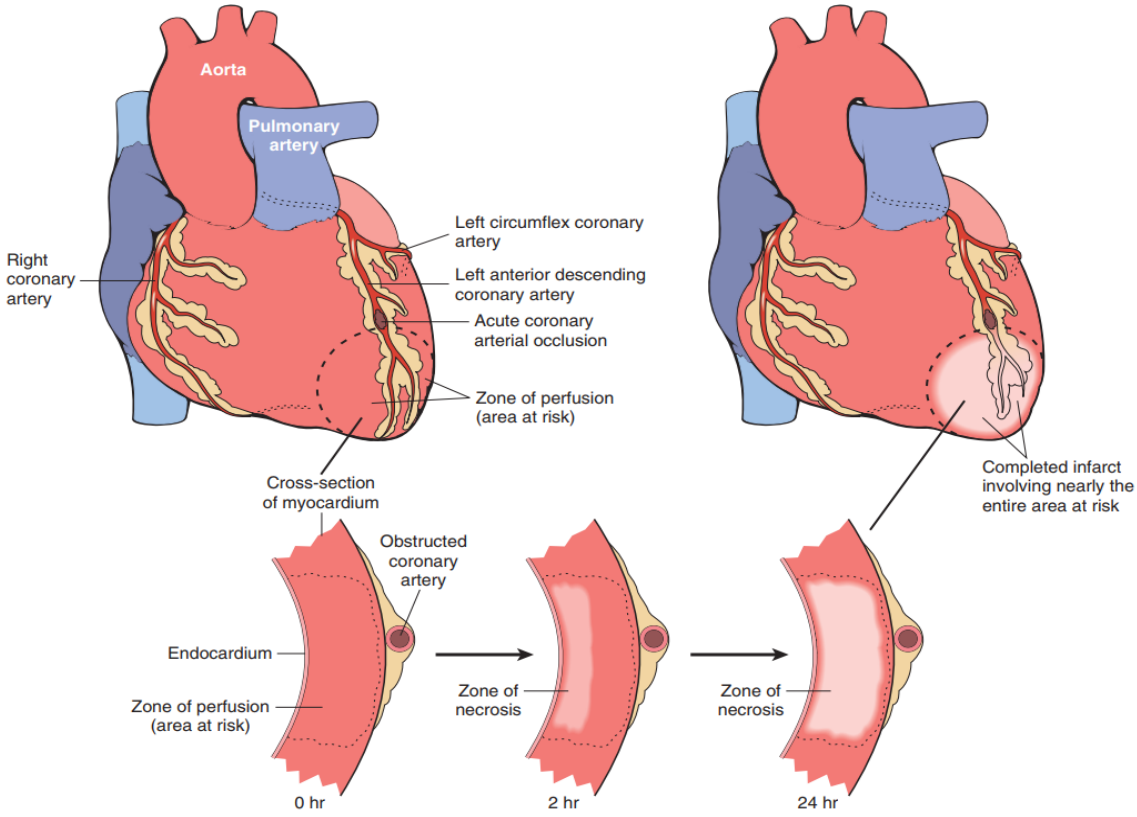
When the **endocardium** is involved in the necrotic process (subendocardial and transmural infarcts), reactive inflammation develops in its tissues, **thrombotic overlays** appear on the endothelium. With **subepicardial** and transmural infarcts, reactive inflammation of the outer shell of the heart is often observed - **fibrinous pericarditis**.

During myocardial infarction , two stages are distinguished:

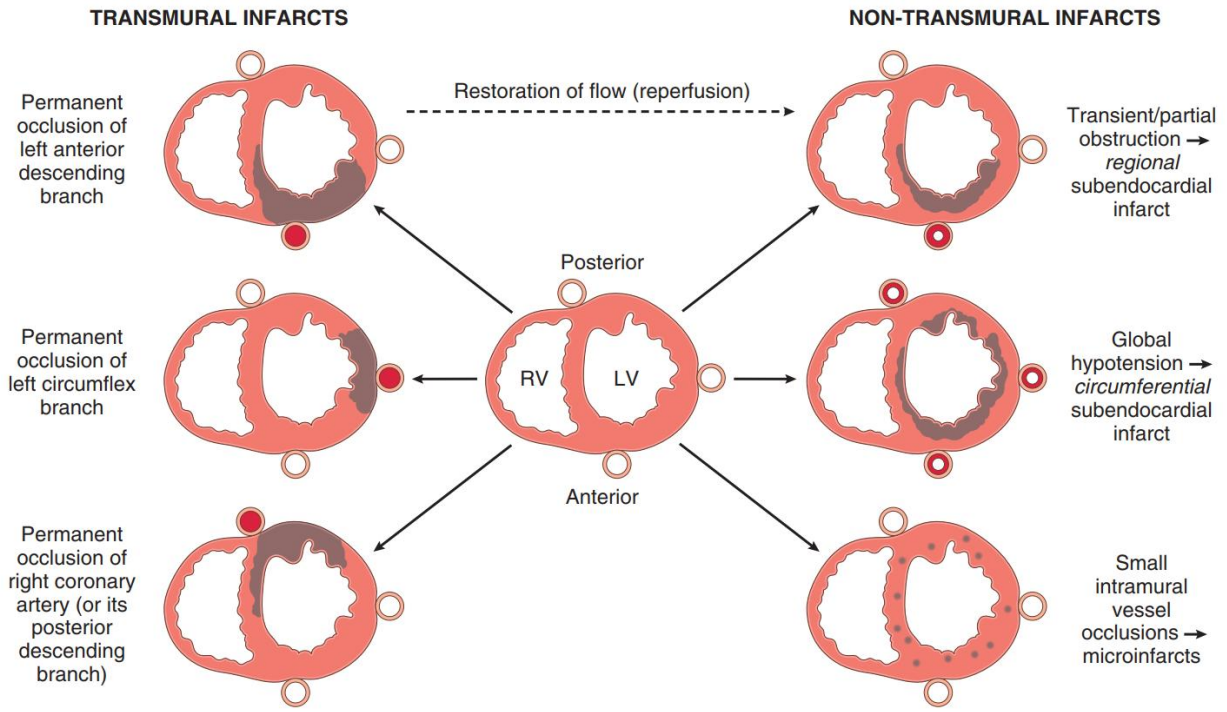
1.necrotic stage

2.stage of scarring

Myocardial necrosis



Correlation of MI with the location and nature of decreased perfusion



The area of necrosis is delimited from the remaining myocardium by a zone of hyperemia and leukocyte infiltration (**demarcation zone**).

The stage of scarring (organization) of a heart attack begins when macrophages come to replace leukocytes. Macrophages take part in the resorption of necrotic masses; lipids, products of tissue detritus, appear in their cytoplasm. The preserved myocardium, especially along the periphery of the scar, undergoes **regenerative hypertrophy**.

Complications of a heart attack are cardiogenic shock, ventricular fibrillation, asystole, acute heart failure, myomalacia (melting of necrotic myocardium), acute aneurysm of the heart, heart rupture with hemopericardium, parietal thrombosis, pericarditis.

Diffuse cardiosclerosis develops due to relative coronary insufficiency with the development of small foci of ischemia with their subsequent sclerosis. Clinically accompanied by attacks of angina pectoris. Often occurs with rhythm disturbances.

Cerebrovascular diseases are characterized by acute cerebrovascular accidents and, in essence, are **cerebral manifestations of atherosclerosis and arterial hypertension**, less often symptomatic hypertension.

As an independent group of diseases, cerebrovascular diseases, as well as coronary heart disease, are singled out due to their social significance.

Among the immediate causes of acute disorders of cerebral circulation, **spasm**, **thrombosis** and **thromboembolism** of the cerebral and precerebral (carotid and vertebral) arteries occupy the main place.

In the group of acute cerebrovascular disorders underlying cerebrovascular diseases, **transient ischemic attack (TIA)** and **stroke** are distinguished.

Morphologically transient ischemic attack (TIA) is characterized by **vascular disturbances** (spasm of arteriols, plasma impregnation of their walls, perivascular

edema and single hemorrhages) and **focal changes in brain tissue** (edema, degenerative changes in neurons). These changes are reversible.

Sometimes perivascular accumulations of hemosiderin is revealed at the place of former small hemorrhages.

A **stroke** is an acute (suddenly) developing local disorder of cerebral circulation, which is accompanied by damage to the substance of the brain and violations of its function.

- **Hemorrhagic stroke**, represented by a hematoma or hemorrhagic impregnation of the substance of the brain (including subarachnoid hemorrhage)
- **Ischemic stroke** (infarction), the morphological expression of which is a infarction or gray softening of the brain

Brain hemorrhage

With the formation of a **brain hematoma**, which occurs in 85% of hemorrhagic strokes, the brain tissue is destroyed at the site of the hemorrhage, a cavity is formed filled with blood clots and softened brain tissue.

Hemorrhage is localized most often in the subcortical zones of the brain and the cerebellum. Strokes with a breakthrough in the ventricles of the brain always end in death.

Ischemic cerebral infarction resulting from thrombosis of atherosclerotically altered precerebral or cerebral arteries has a diverse localization. Ischemic infarctions looks like a focus of gray softening of the brain. Microscopic examination of the medium of necrotic masses can reveal dead neurons.

INFORMATIONAL AND METHODOLOGICAL PART

MAIN LITERATURE

1. Pathomorphology : textbook / ed. by I.V. Sorokina, V.D. Markovskyi, D.I. Halata. - 2nd ed. - Kyiv : AUS Medicine Publishing, 2020. - 327 p., [10] col. inserts : tab.

2. Klatt, E. C. Robbins and Cotran Atlas of Pathology : [with Student Consult Online Access] / Edward C. Klatt. - third edition. - Philadelphia : Elsevier, 2015. - 587 p. : il.

3. Robbins Basic pathology / [ed. by] Vinay Kumar, Abul K. Abbas, Jon C. Aster. - 9th ed. - [Philadelphia] : Elsevier ; Saunders. - 910 p. : ill., scheme, tab.

ADDITIONAL LITERATURE

1. Sobotta. Atlas of human anatomy. [V. 1]. General anatomy and musculoskeletal system / ed. by F. Paulsen, J. Waschke. - 15th ed. - München : Elsevier. Urban & Fischer, 2011. - 400 p. : ill., col. ill.

2. Sobotta. Atlas of human anatomy. [V. 2]. Internal organs / ed. by F. Paulsen, J. Waschke. - 15th ed. - München : Elsevier. Urban & Fischer, 2011. - 259 p. : ill., col. ill.

3. Sobotta. Atlas of human anatomy. [V. 3]. Head, neck, and neuroanatomy / ed. by F. Paulsen, J. Waschke. - 15th ed. - München : Elsevier. Urban & Fischer, 2011. - 370 p. : ill., col. ill.

4. Weir & Abrahams' imaging atlas of human anatomy / ed.: J. D. Spratt [and oth.] ; consultant eds.: J. Weir, P. H. Abrahams. – 5th ed. - [S.l.] : Elsevier, 2017. - xvi, 263 p. : ill.

NORMATIVE LEGAL ACTS AND DOCUMENTS

1. Order of the Ministry of Health of the Republic of Belarus No. 111 of 06/01/1993 "On further improvement of the pathological service of the Republic of Belarus"

Access mode: http://patan.by/menyu/administrativnyie-proczeduryi.html - The date fccess: 20.03.2022.

ELECTRONIC DATABASES

1. Physician's consultant. Electronic Medical Library = Consultant of the doctor. Electronic medical library [Electronic resource] / Publishing group "GEOTAR-Media", LLC "IPUZ". – Access mode: http://www.rosmedlib.ru/ . – Access date: 03/15/2022.

2. Springer Link [Electronic resource] / Springer International Publishing AG. – Access mode: https:link.springer.com. – Date of access: 03/15/2022.