

VOLGOGRAD STATE
MEDICAL UNIVERSITY
Department of Pathological Anatomy

Atherosclerosis and arteriosclerosis. Hypertonic disease and arteriolosclerosis.

Volgograd

1. **Purpose:** To study the causes, mechanisms of development of the atherosclerotic process. Consider the main clinical and morphological forms of hypertension.
2. **Requirements for the student's level** of mastering the discipline – pathological anatomy.

Theoretical aspects:

ATHEROSCLEROSIS

ATHEROSCLEROSIS is a chronic disease resulting from a violation of fat and protein metabolism, characterized by damage to the arteries of elastic and muscular-elastic types 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 a lack of blood supply to the organs.

Atherosclerosis is the most common type of arteriosclerosis, reflecting a violation of lipid and protein metabolism (metabolic arteriosclerosis).

The stages of the pathogenesis of atherosclerosis, given its multifactorial nature, can be represented as follows:

1. Development of atherogenic dyslipoproteinemia (in most cases), 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. Increase in vascular permeability and release of plasma components, including lipoproteins, into the intima.
4. Adhesion of platelets and monocytes to the endothelium (under the influence of adhesins expressed when it is damaged); 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 to the intima and proliferation of smooth muscle cells (SMCs) under the influence of thrombotic growth factor secreted by macrophages, endothelium and SMCs themselves, which adopt a synthetic phenotype (usually the contractile phenotype prevails), synthesize collagen and elastic fibers, proteoglycans, etc. .e. create the basis of atherosclerotic plaque.
6. Further modification of lipoproteins in the intima (mainly peroxidation under the influence of factors produced by macrophages), 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 xanthoma cells. part of xanthoma cells is formed from SMCs, which, possessing receptors for modified β -VLDLP, absorb them unregulated.
7. Subsequent changes in the plaque are associated with the formation of capillaries in it under the influence of growth factors (RF), the involvement of other cellular elements - T- and B-lymphocytes, fibroblasts, necrosis of the central sections, sclerosis, hyalinosis, calcification.

Macroscopically, the changes developing in the artery wall during pre-atherogenesis can be divided into the following stages:

Fat spots and streaks (lipoidosis). They appear in patches of yellowish or gray-yellow color, forming small (usually up to 1 cm longitudinal) foci that do not rise above the surface. Microscopically, these formations consist of extracellular lipids and foamy (xanthoma) cells

containing a large amount of lipids and staining with Sudan III yellow (macrophages and smooth muscle cells). This stage is reversible, but can go to the next.

Atheromatous (fibrous, liposclerotic) plaques. They are white or whitish-yellow chaotically located dense formations up to 1.5 cm in diameter, protruding above the surface of the intima. Plaques are especially often located in the area of arterial branching and bending, where the greatest hemodynamic loads are noted. On the cut, the plaque consists of a fibrous cap, under which there is a small amount of yellowish contents. The central section of large plaques is represented by mushy, or atheromatous (from the Greek *athere* - gruel) masses. Microscopic examination of the fibrous plaque consists of three components: cellular, fibrous and lipid. Cells localized along the periphery of the plaque are represented by myocytes, macrophages, T-lymphocytes, and individual leukocytes. The fibrous component consists of the extracellular matrix of connective tissue - collagen, elastic fibers and proteoglycans. The third component consists of accumulations of lipids (foam cells). They occupy the entire central part of the plaque, which is detritus, which consists of lipids, cholesterol crystals, plasma proteins, destroyed cells and Ca^{2+} + salts. In addition, vascularization is noted along the periphery of the plaque due to the supply of lipoproteins and plasma proteins that promote plaque growth. Located in arteries of the muscular-elastic type (for example, in the coronary arteries of the heart), atherosclerotic plaque leads to atrophy and sclerosis of the muscular membrane of the vessel.

Complicated lesions. They reflect further structural changes in atherosclerotic plaques, manifested by their ulceration and rupture of the vascular wall. Atheromatous ulcers occur due to the disintegration of the contents of the plaques and their fibrous caps. In this case, the formation of parietal or obstructing blood clots is possible with the subsequent development of thromboembolism. When the wall of the artery is ruptured or the vessels newly formed in the plaque are destroyed, hemorrhage occurs as an intramural dissecting hematoma, and there is a high probability of the formation of an atherosclerotic vascular aneurysm.

On examination, it is not always possible to say exactly what stage of atherosclerosis is in question. Therefore, on the basis of more subtle morphological methods, morphogenetic stages of the disease are distinguished: lipoidosis (corresponds to the stage of fat spots and stripes), liposclerosis, atheromatosis (reflects the stage of fibrous plaques), ulceration and atherocalcinosis.

Arterial hypertension

Arterial hypertension is understood as a persistent increase in blood pressure: systolic - above 140 and diastolic - above 90 mm Hg.

In most cases (90 -95%), the cause of hypertension cannot be established. Such hypertension was called primary and was singled out as an independent nosological form - hypertension (the term "essential hypertension" is often used abroad).

Arterial hypertension, which is a symptom of any other disease, is called secondary, or symptomatic.

Types of symptomatic hypertension:

a. Renal (associated with kidney disease - nephrogenic or renal vascular - renovascular)

b. Endocrine (with disease or Itsenko-Cushing's syndrome; primary and secondary aldosteronism, pheochromocytoma, etc.)

in. Neurogenic (with an increase in intracranial pressure due to trauma, tumor, abscess, hemorrhage; with damage to the hypothalamus and brain stem; associated with psychogenic factors).

d. Others (caused by coarctation of the aorta and other vascular anomalies; increase in the volume of circulating blood with excessive transfusion, polycythemia, etc.).

Hypertension is a chronic disease, the main clinical manifestation of which is a prolonged and persistent increase in blood pressure (hypertension). Described as an independent disease of neurogenic nature, as a "disease of unresponsive emotions" by the domestic clinician G.F. Lang. (1922).

Pathogenesis.

- The development of arterial hypertension can be caused by defects in any links (pressor and depressor) of the mechanism that determines normal pressure (barostat).

- The main role in the consolidation, chronicity of arterial hypertension is played by the kidneys.

- Several theories of the pathogenesis of hypertension have been proposed, which interpret the essence of the starting (initial) pathogenetic link in different ways.

1. The theory of G.F. Lang and A.L. Myasnikov. - The initial pathogenetic factor in the development of hypertension is psychoemotional overstrain with a decrease in the inhibitory effect of the cerebral cortex, which it normally exerts on the subcortical autonomic centers, primarily pressor centers, which causes their persistent overexcitation.

2. Theory A. Guyton et al. - The initial factor in the development of hypertension is a genetically determined defect in the renal volumetric mechanism of blood pressure regulation, which consists in a decrease in the ability of the kidneys to excrete Na and water in response to inevitable episodes of an increase in blood pressure due to various reasons.

Trigger (trigger) - increased salt intake.

3. Membrane theory of Yu.V. Postnov and SN Orlov. - The initial factor is a generalized hereditary defect of the membrane ion pumps of the cell, which leads to an excess of Ca^{2+} and Na^{+} in the cytoplasm of smooth muscle cells and causes their spasm, as well as an increase in sensitivity to pressor factors.

- The listed theories do not exclude, but complement each other.

- With arterial hypertension, structural changes occur in small muscle arteries and arterioles, including hyperplasia and hypertrophy of smooth muscle cells, hyalinosis (sclerosis). This leads to a thickening of the wall and narrowing of the vessel lumen and an even greater increase in peripheral vascular resistance, as a result of which arterial hypertension becomes persistent.

- Morphological changes in hypertension are very diverse, reflecting the nature and duration of its course.

The nature of the course of hypertensive disease can be malignant (malignant hypertension) and benign (benign hypertension).

I. Malignant hypertension.

- Malignant hypertension is rare today.

- The level of diastolic pressure exceeds 110 - 120 mmHg. Art.

- May occur primarily or complicate benign hypertension.

- Rapidly progressing, leading to death (in the absence of adequate therapy) in 1 - 2 years.

- It occurs mainly in men aged 35-50 years, sometimes up to 30 years.

Morphological changes.

- Fibrinoid necrosis of vessels with accessory thrombosis and associated organ changes: heart attacks, hemorrhages, rapidly developing renal failure.
- Bilateral edema of the optic nerve head, accompanied by protein effusion and hemorrhage in the retina.
- Malignant nephrosclerosis (Fara) develops in the kidneys, which is characterized by fibrinoid necrosis of arterioles and capillary loops of the glomeruli, edema and hemorrhages. Macroscopic picture: the appearance of the kidneys depends on the presence and duration of the pre-existing benign phase of hypertension, and therefore the surface can be smooth or granular. Petechial hemorrhages are characteristic, giving the kidney a variegated appearance.
- The rapid progression of the process leads to the development of kidney failure and death.
- fibrinoid necrosis of arterioles, edema, hemorrhages develops in the brain.
-

II. Benign hypertension.

- Given the long-term development of the disease, there are three stages that have certain morphological development: preclinical, common changes in arteries, changes in organs due to changes in arteries and impaired intraorganic circulation.

A hypertensive crisis - a sharp increase in blood pressure due to spasm of arterioles - can occur at any stage.

Morphological changes during a crisis.

and. Spasm of arterioles: corrugation and destruction of the basement membrane of the endothelium with a peculiar arrangement in the form of a stockade.

b. Plasma impregnation.

in. Fibrinoid necrosis of the arteriole wall.

Thrombosis.

e. Diapedetic hemorrhage.

Forecast and causes of death.

- Most people with benign hypertension die from heart failure, myocardial infarction, stroke (ischemic or hemorrhagic), or intercurrent illness.
- Approximately 5% of hypertensive patients develop malignant hypertension and die from kidney failure, heart failure, or cerebral stroke.
- A very small number of patients over 60 years of age die from renal failure due to athero-arteriosclerotic nephrosclerosis (a combination of changes associated with progressive obliteration of the vascular bed caused by arteriol- and atherosclerosis).

Lesson plan.

Mandatory micro-, macro-preparations:

1. Micropreparation "Aortic liposclerosis" (staining with hematoxylin and eosin, Sudan III). Pay attention to the localization and structure of the plaque (contents, tire, vascularization,

characteristic cells, calcification, proliferation of connective tissue). Note the color of the plaque content and cytoplasm of characteristic cells when stained with Sudan III.

2. Macropreparation "Atherosclerosis of the aorta with abdominal aneurysm". Pay attention to the localization, shape, size, surface, color, consistency of different variants of aortic lesions; vessel lumen; localization, shape, size of the aneurysm; consistency, color, thickness, structure of its wall, cavity content.

3. Macropreparation "Atherosclerotic nephrosclerosis". Pay attention to the size, nature of the surface and consistency of the kidneys, the thickness of the cortical and medullary layers in the section.

4. Macropreparation "Gangrene of the lower extremity". Pay attention to the volume, color and texture of the tissue, the border of the affected area.

5. Electronogram "Arteriole spasm". Pay attention to the contents and shape of the lumen of the vessel, the location of endothelial cells, the profile and condition of the basement membrane, swelling and foci of destruction of the arteriole wall, the state of the tissue surrounding the vessel.

6. Macropreparation "Heart hypertrophy". Pay attention to the size of the heart, the thickness of the walls of the atria and ventricles, the volume of the papillary and trabecular muscles, the size of the cavities, the consistency and color of the myocardium.

7. Micropreparation "Myocardial hypertrophy" (staining with hematoxylin and eosin). Pay attention to the size of the cardiomyocytes, the size and hyperchromia of the nuclei, the number of stroma.

8. Macropreparation "Arteriolosclerotic nephrosclerosis (nephrocirrhosis)". Pay attention to the size, nature of the surface and consistency of the kidneys, the thickness of the cortical and medullary layers in the section.

9. Micropreparation "Arteriolosclerotic nephrosclerosis" (staining with hematoxylin and eosin). Pay attention to the thickness, color, structure of the walls and the lumen of the bringing arterioles; size, shape, structure and color of affected glomeruli, condition of tubules, stroma and preserved glomeruli.

10. Macropreparation "Hemorrhage in the brain". Pay attention to the localization, size, color, shape, consistency and contents of the focus in the brain tissue, the state of the surrounding tissue.

11. Micropreparation "Large focal cardiosclerosis" (staining with hematoxylin and eosin, picrofuchsin). Pay attention to the localization, size, structure of the connective tissue focus in the myocardium, the size of the cardiomyocytes surrounding the focus, the size and hyperchromia of their nuclei. Mark the color of the connective and muscle tissue when stained with picrofuchsin.

QUESTIONS

Choose one correct answer

1. In the mechanism of hypertensive disease, the leading role is played by
 - A. Arteriosclerosis.
 - B. Atherosclerosis.
 - B. Increased tone of arterioles.
 - D. Calcification of the middle aortic membrane.
 - D. Inflammation of the arteries.
2. Myocardial hypertrophy is a result
 - A. Expansion of the cavities of the heart.
 - B. Decrease in the number of muscle fibers.
 - B. Reproduction of cardiomyocytes.
 - D. Increase in the size of individual fibers.
 - D. Thickening of the endocardium.
3. Distinguish the following clinical and morphological form of hypertensive disease
 - A. Mesenteric.
 - B. Hepatic.
 - V. Brain.
 - G. Splenic.
 - D. Pulmonary.
4. For the renal form of hypertensive disease, the following morphological changes are characteristic
 - A. Hydronephrosis.
 - B. Amyloidosis.
 - B. Pyelonephritis.
 - D. Arteriolosclerotic nephrosclerosis.
 - D. Atherosclerotic nephrosclerosis.
5. About hypertrophy of the heart in an adult is said when its mass exceeds
 - A. 100 g.
 - B. 200
 - H. 350
 - G. 600
 - D. 750
6. In the malignant course of hypertensive disease, a process develops in the kidneys, which is called
 - A. Primary wrinkled kidney.
 - B. Secondary contracted kidney.
 - B. Nephrosclerosis Pharah.
 - G. Hydronephrosis.
 - D. Amyloidosis.
7. Partial ligation of the renal arteries probably leads to
 - A. To reflex anuria.
 - B. To persistent hypertension.
 - B. To kidney necrosis.
 - D. To hypotension.
 - D. To transient hypertension.
8. In the chronic course of hypertensive disease, changes in arterioles are of the nature
 - A. Sclerosis.
 - B. Fibrinoid necrosis.
 - B. Hyalinoza.
 - D. True A and B.
 - D. True A and B.
9. The increase in heart mass in hypertensive disease is due to
 - A. An increase in the number of muscle fibers.
 - B. By increasing the size of each fiber.
 - B. Increased intermuscular tissue.
 - D. True A and B.
 - D. Verno B and C.
10. In hypertensive disease, elastic type arteries develop
 - A. Atherosclerosis
 - B. Elastofibrosis.
 - B. Fibrinoid necrosis.
 - D. True A and B.
 - D. True A and B.
11. In the second stage of hypertensive disease with a benign course in the myocardium,
 - A. Hypertrophy.
 - B. Cardiosclerosis.
 - B. Necrosis.
 - D. True A and B.
 - D. True A and B.
12. With a benign course of hypertensive disease in the kidneys, changes develop, which are called
 - A. Secondary contracted kidney.
 - B. Primary contracted kidney.
 - B. Nephrosclerosis Pharah.
 - D. Kimmelfel-Wilson syndrome.
 - D. Polycystic.
13. The form of acute ischemic heart disease is
 - A. Cardiosclerosis.
 - B. Atherosclerosis.
 - B. Myocardial infarction.
 - D. Chronic aneurysm of the heart.
14. The form of chronic ischemic heart disease is
 - A. Cardiosclerosis.

- B. Myocardial infarction.
- B. Chronic aneurysm of the heart.
- D. True A and B.
- D. True A and B.

15. What is the cause of death in hypertensive disease?

- A. Purulent intoxication.
- B. Pyopneumothorax.
- B. Hemorrhage in the brain.
- D. Fat embolism.
- D. Pancreatic necrosis.

16. Atherosclerosis is macroscopically manifested by the development

- A. Fat spots and stripes.
- B. Fibrous plaques.
- B. Complicated lesions (ulceration, thrombosis, hemorrhage) and calcification.
- D. Correct A, B and C.
- D. Verno B and C.

17. In case of rupture of the wall of an atherosclerotic aortic aneurysm, histologically determine

- A. Destruction of elastic fibers.
- B. Rupture of the aortic wall.
- B. Hemorrhages in the aortic wall.
- D. All of the above is true.
- D. Verno B and C.

18. In case of hypertension in arterioles and small arteries,

- A. Hyalinosis.
- B. Arteriosclerosis.
- B. Fibrinoid necrosis.
- D. All of the above.
- D. True A and B.

19. List the clinical and morphological forms of atherosclerosis

- A. The functional form of atherosclerosis.
- B. Atherosclerosis of the arteries of the lower extremities.
- B. Atherosclerosis of the renal arteries.
- D. Atherosclerosis of the aorta.
- D. Mesenteric form of atherosclerosis.
- E. True A and D.
- G. True B, C, D and D.

20. Macroscopic characteristics of the aorta in hypertensive disease:

- A. Intima looks like pebbled skin.
- B. Parietal blood clots.
- B. Fibrous plaques in the intima.
- D. Circular calcification of the middle membrane.

- D. In the ascending department, a saccular aneurysm often develops.
- E is correct G and D.
- G. Correct A, B and C.

21. Morphology of manifestation of the cerebral form of hypertensive disease:

- A. Meningitis.
- B. Multiple sclerosis.
- B. Hematoma.
- D. Ischemic infarction.
- D. Cyst.
- E. Correct A, B and D.
- J. Correct C, D and D.

22. Characteristics of atherocalcinosis in hypertensive disease:

- A. Metastatic calcification.
- B. Dystrophic calcification.
- B. Metabolic calcification.
- D. It is accompanied by hypercalcemia.
- D. Pathogenetically associated with arteriolosclerotic nephrosclerosis.

23. Changes in arterioles characteristic of hypertensive crisis:

- A. Spasm of arterioles.
- B. Plasma impregnation.
- B. Fibrinoid necrosis.
- G. Hyalinosis.
- D. Thrombosis.
- E. All of the above is true
- G. Correct A, B and C.

24. Changes in brain tissue that can develop during a hypertensive crisis:

- A. Hemorrhage per diapedesin.
- B. Hematoma.
- C. Focuses of necrosis.
- D. Cysts.
- E. Encephalitis.
- F. All of the above is true
- G. Correct A, B and C.

25. Which of the listed changes correspond to atherosclerosis?

- A. Lipid infiltration of significantly thickened aortic intima.
- B. Lipid infiltration of a significantly thickened middle lining of the aorta.
- B. Necrosis and cystic changes in the middle aortic membrane.
- D. Calcification of the middle aortic membrane.
- D. Productive vasculitis vasa vasorum.

26. Typical changes in the kidneys in atherosclerosis of the renal arteries:
 A. Arteriolosclerotic nephrosclerosis.
 B. Atherosclerotic nephrosclerosis.
 C. Hydronephrosis.
 D. Kidney infarction, scars.
 E. Focuses of wedge-shaped atrophy.
 F. Correctly A, B and D.
 G. True B, D and E.

27. Signs characteristic of the dolipid stage of atherosclerosis?
 A. Increased endothelial permeability.
 B. Accumulation of acidic glycosaminoglycans in the intima.
 C. The emergence of xanthoma cells.
 D. Destruction of the basement membrane of the intima.
 E. Destruction of collagen and elastic fibers.
 F. True A and B.
 G. Verno B and G.
 H. All of the above is true.

28. Indicate the morphological changes in the heart directly related to atherosclerosis of the coronary arteries.
 A. Obliteration of the pericardial cavity.
 B. Myocardial infarction.
 C. Hairy heart.
 D. Aortic heart disease.
 E. Myocardial hypertrophy.

29. Specify the process developing in the small intestine with atherosclerosis of the mesenteric artery
 A. Gangrene.
 B Polyp.
 C. Enteritis.
 D. Hemorrhage.
 E. Ulcer.

30. In the stage of lipoidosis in atherosclerosis, lipids are absorbed
 A. Virchow cells.
 B. Xanthoma cells.
 C. Cells of Pirogov-Langhans.
 D. Epithelioid cells.
 E. Friedlander Diplobacillus

Situational tasks.

Situational task 1.

The patient, 39 years old, complains of severe headaches in the occipital region. From the anamnesis it was found that the pain appeared about 5 months ago. Prior to this, the patient's condition was satisfactory, but periodically there was an increase in blood pressure. On examination, the skin and visible mucous membranes are hyperemic. BP is 185/125 mm Hg, the liver is enlarged. The legs and feet are pasty. A blood test revealed erythrocytosis ($6.7 \cdot 10^{12}$), leukocytosis ($11.2 \cdot 10^9$), thrombocytosis ($650 \cdot 10^9$).

1. What forms of pathology have developed in the patient ?. Argument your answer.
2. Can we conclude that the patient, besides other forms of pathology, has arterial hypertension? What additional research is needed to determine its pathogenesis?
3. Is it possible a pathogenetic relationship between elevated blood pressure and the existing changes in the blood in this case? Justify the answer.

Situational task 2.

Patient X, 37 years old, at a doctor's appointment complains of episodes of severe headache, flashing of "flies" and the appearance of a "mesh" before the eyes, flushing of the face, increased sweating, dizziness, palpitations and pain in the region of the heart, large tremors, feeling of unmotivated anxiety when performing hard physical work. At rest, blood pressure 136/85 mm Hg, heart rate 80 beats / min, blood and urine test data were unchanged. With physical exertion, blood pressure 230/165 mm Hg, heart rate 188 beats / min, in the blood test glucose 10.5 mmol / l, in the analysis of urine the level of catecholamines and their metabolites is increased. The radiograph of the lumbar region shows a significant increase in the size of the right adrenal gland.

1. Name and justify the possible forms of pathology in the patient? Justify the answer.

2. What are the causes and pathogenesis of blood pressure elevations in this patient? Argument your answer.
3. What is the mechanism of development of each of the symptoms?

Situational task 3.

Patient A., 57 years old, head of a large enterprise, was hospitalized according to the results of a preventive examination, during which it was revealed: BP 170 \ 100 mm Hg. , Heart rate 89, rhythmic pulse., Expansion of the borders of the heart to the left., Strengthening of the apical point, increase in BCC by 20%. The ECG shows signs of left ventricular hypertrophy. Increased tortuosity of the vascular pattern of the fundus and narrowing of the arterioles. In a blood test, hypernatremia, aldosterone levels within normal limits, hypercholesterolemia. The patient is emotional, agitated, does not smoke.

1. What form of pathology developed in this patient?
2. What are the most probable causes and main links of pathogenesis?
3. How can you explain the fact of the development of hypernatremia and hypervolemia with a normal content of aldosterone?
4. What complications of the disease are possible in this patient?

List of recommended literature:

Basic literature:

1. "Basic pathology" Vinay Kumar, Ramzi S. Cotran, Stanley L. Robbins, 1997.

Additional literature:

1. "Pathology. Quick Review and MCQs" Harsh Mohan, 2004.
2. "Textbook of Pathology " Harsh Mohan, 2002.
3. "General and Systemic Pathology" Joseph Hunter, 2002.
4. "General and Systematic Pathology " Ed. J.C.E. Underwood – Edinburgh: Churchill Livingstone, 1996 (2th).
5. "Histology for Pathologist" Ed. S.S.Sternberg – Philadelphia: Lippincott Raven Publ, 1997 (2th).
6. "Histopathology. A Color Atlas and Textbook" Damjanov I., McCue P.A. – Baltimore, Philadelphia, London, Paris etc.: Williams and Wilkins, A Waverly Co., 1996.
7. "Muir's Textbook of Pathology" Eds. R.N.M. MacSween, K. Whaley London: ELBS, 1994 (14th).
8. "Pathology" Eds. Rubin, J.L. Farber – Philadelphia: Lippincott Raven Publ, 1998 (3th).
9. "Pathology Illustrated" Govan A.D.T., Macfarlane P.S., Callander R. – Edinburgh: Churchill Livingstone, 1995 (4th).
10. "Robbins Pathologic Basic of Disease" Eds. R.S.Cotran, V.Kumar, T.Collins – Philadelphia, London, Toronto, Montreal, Sydney, Tokyo: W.B.Saunders Co., 1998 (6th).
11. "Wheater's Basic Histopathology. A Color Atlas and Text" Burkitt H.G., Stevens A.J.S.L., Young B. – Edinburgh: Churchill Livingstone, 1996 (3th).
12. "Color Atlas of Anatomical Pathology" Cooke R.A., Steward B. – Edinburgh: Churchill Livingstone, 1995 (10th).
13. "General Pathology " Walter J.B., Talbot I.C. – Edinburgh: Churchill Livingstone, 1996 (7th).
14. "Concise Pathology" Parakrama Chandrasoma, Glive R. Taylor.
15. "Pathology" Virginia A. LiVolsi, Maria J. Merino, John S. J. Brooks, Scott H. Saul, John E. Tomaszewski, 1994.

16. "Short lectures on pathology" Zagoroulko A., 2002
17. "Robbins pathologic basis of diseases" Cotran R., Kumar V., Collins T.
18. "General pathology" Dr. Fatma Hafez, 1979.
19. "Anderson's Pathology " Damjanov I., Linder J. – St. Louis: Mosby Inc., 1995 (10th).

<https://www.volgmed.ru/ru/depts/list/69/>

<https://volgmu-pat-anat.3dn.ru/>

<https://webpath.med.utah.edu/>