Case Report

Stenting of the artery of Dr A.N. Kazantsev in the acute period of ischemic stroke

Anton N. Kazantsev, Alina S. Zharova, Ekaterina V. Sokolova, Alexander V. Korotkikh

Abstract

The A.N. Kazantsev artery is a vessel starting from the common carotid artery with subsequent bifurcation into 2 vessels of equal size—the internal carotid artery (ICA) and the persistent embryonic hypoglossal artery (PEHA). Until now, this artery has been considered as the ICA. However, according to all existing classifications, the ICA in the cervical segment does not have arterial branches. In addition, in view of the comparable sizes of PEHA and ICA, PEHA itself cannot be considered a branch of the ICA. Thus, by the right of the first description, the authors of the article named this vascular formation as the A.N. Kazantsev artery, which forms a bifurcation of the PEHA and ICA. In this clinical case, carotid angioplasty (CAS) was performed with stenting of 80% stenosis of the A.N. Kazantsev artery in the most acute period of acute cerebrovascular accident (ACV). According to angiography, the following was also revealed: the presence of PEHA, extending from the A.N. Kazantsev artery 5 cm above its mouth, connecting with the main artery; stenosis of the right vertebral artery 60% at the mouth; hypoplastic left vertebral artery with aplasia of the V4 segment; open circle of Willis (VC): absence of both posterior communicating arteries (PCA). Due to the high risk of recurrent CVA due to clamping of the A.N. Kazantsev artery during CEA, a multidisciplinary consultation decided to implement an emergency CAS of the A.N. Kazantsev artery. The distal embolism protection system FilterWire was inserted into the proximal part of the basilar artery through the radial artery on the left. The distal embolism protection system RX Accunet was inserted into the distal parts of the left ICA through the left common femoral artery. According to Seldinger, an Acculink stent 7-10 × 30 mm was inserted into the affected area of the A.N. Kazantsev artery, positioned and opened. The postoperative period was uneventful. ACV did not recur. Conducted dual antiplatelet therapy (acetylsalicylic acid

Keywords:
Carotid angioplasty with stenting
Persistent embryonic hypoglossal artery
Carotid endarterectomy
Acute period of stroke
Stenting of the internal carotid artery
A.N. Kazantsev artery

Article history:
Received 21 June 2022
Revised 4 July 2022
Accepted 6 July 2022

Funding: The work has no funding.
Corresponding author at: Russian Federation, Kostroma region, Kostroma, Mira Ave., 114, index 156013
E-mail address: dr.antonio.kazantsev@mail.ru (A.N. Kazantsev).
https://doi.org/10.1016/j.radcr.2022.07.034
1930-0433/© 2022 The Authors. Published by Elsevier Inc. on behalf of University of Washington. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)
Introduction

Emergency correction of hemodynamically significant stenosis of the internal carotid artery (ICA) is currently an important and little-studied section of carotid surgery [1–5]. Recent studies do not come to a consensus on the need for urgent interventions in the brachiocephalic system in the acute period of acute cerebrovascular accident (ACV) [6–10]. But the current Russian recommendations do not prohibit performing carotid endarterectomy (CEE) or (CAS) on an emergency basis [11]. Moreover, according to this document, the operation of choice is CEA, and CAS takes only an alternative position [11]. However, well-known domestic works are most often devoted to the analysis of the results of only one of these reconstruction methods on an emergency basis [12–16]. However, the only Russian multicenter study published in 2021 compared the results of both methods of revascularization [17]. The authors concluded that CEA is a less preferable option for correcting hemodynamically significant ICA stenosis in the urgent mode due to the high risk of developing hemorrhagic transformation of the ischemic focus in the brain and all adverse cardiovascular events [17]. Thus, according to the main conclusion of this study, ICA stenting is a safer procedure relative to open surgical interventions in patients in the most acute period of stroke [17]. Some difficulties are caused by the choice of strategy for emergency cerebral revascularization in the presence of a variant structure of the carotid bifurcation. In this situation, we are talking primarily about the persistent embryonic hypoglossal artery (PEHA), which connects the ICA and the basilar artery [18]. The frequency of its diagnosis in the general population does not exceed 0.3%, and with comitant atherosclerosis of extracranial arteries, it is a rare exception [18]. To date, none of the major studies of the leading vascular centers in Russia have reported CEE or CAS in the presence of PEHA, which creates uncertainty in the choice of treatment strategy for this complex cohort of patients [19–23].

A separate issue concerns the terminology of the topographic anatomy of the carotid bifurcation under conditions of a functioning PEHA. Due to the rarity of this variant of the structure, in all atlases of human anatomy, and in particular, in the most popular publication in Russia, edited by Sinelnikov R.D., the following classification of parts of the ICA is distinguished: cervical, cavernous, stony and cerebral [24]. The cervical segment is understood as an area of the ICA that is localized extracranially and does not give off any arterial branches [24]. But since PEHA is precisely a branch of the ICA, then the definition of the term “cervical part of the ICA” loses its relevance. At its core, this segment will start from the place of origin of the PEHA to the entrance to the carotid canal, because it is in this area that the ICA has no other arterial branches. And the segment between the mouth of the ICA to the PEHA remains outside the nomenclature [24]. And if a hemodynamically significant stenosis is localized precisely in this zone, then it will be deprived of any exact name [24]. Thus, due to the lack of regulatory terminology, the authors of this work, who described an emergency reconstructive intervention on the arterial segment from the mouth of the ICA to the PEHA, introduced a new term “A.N. Kazantsev artery”, which defines this segment of the carotid basin.

The purpose of this article was to describe a clinical case of emergency CAS of the A.N. Kazantsev artery in the most acute period of stroke.

Clinical example

Man, 60 years old. He was admitted on an emergency basis to the State Budgetary Institution of Health “City Alexandrovskaya Hospital,” St. Petersburg. From the anamnesis, it is known that about an hour ago he felt weakness in the upper and lower extremities on the right, confusion of speech. By the time of admission to the institution, the neurological deficit had regressed. According to the data of multislice computed tomography of the brain, data for ischemic stroke were not established.

A color duplex scan of the brachiocephalic arteries was performed, according to which 80% stenosis of the left ICA was visualized with signs of unstable ASP (bleeding under the ASP cover). Five centimeter above the mouth of the ICA, there is an additional large branch extending into the cranium without signs of stenosis.

Examined by a neurologist, the diagnosis was made: transient ischemic attack in the basin of the left middle cerebral artery. A multidisciplinary consultation (neurologist, cardiovascular surgeon, endovascular surgeon, neurosurgeon, cardiologist, resuscitator, anesthesiologist) in view of the presence of hemodynamically significant stenosis of the left ICA with signs of unstable ASP, the absence of neurological deficit, decided to perform angiography with subsequent decision on the issue of emergency CAS.

Angiography revealed: stenosis of the A.N. Kazantsev artery on the left 80% (Fig. 1), the presence of PEHA, extending from the A.N. Kazantsev artery 5 cm above its mouth, connecting with the main artery (Fig. 2); stenosis of the right vertebral artery 60% at the mouth (Fig. 3); hypoplastic left vertebral artery with aplasia of the V4 segment (Fig. 4); open circle of Willis (VC): absence of both posterior communicating arteries (PCA) (Fig. 5).

Due to the high risk of recurrent CVA due to clamping of the A.N. Kazantsev artery during CEE, a multidisciplinary council (with the same composition) decided to implement an emergency CAS of the A.N. Kazantsev artery.
The course of the operation: after processing the surgical field under m/a Sol. Lidocaini 0.2%—1 ml performed puncture of the right radial artery. Sheath 6F installed. A guiding catheter JR 5.0 6F SH was installed along the diagnostic guidewire at the mouth of the right vertebral artery. The distal embolism protection system FilterWire 3.5-5.5 mm was inserted into the proximal part of the basilar artery, and opened. On the diagnostic guidewire, the 6F sheath in the common femoral artery on the left is replaced by 7F. A JR 5.0 7F SH guiding catheter was inserted through the diagnostic guide into the left common carotid artery (CCA). The system of protection against distal embolism RX Accunet 6.5 mm was inserted into the distal parts of the left ICA. According to Seldinger, an Acculink stent 7-10 × 30 mm was inserted into the affected area of the A.N. Kazantsev artery, positioned and opened. The delivery system has been removed. On control angiography, residual stenosis in the area of stenting of the left ICA up to 60%, no signs of spasm. According to Seldinger, a balloon catheter Viatrac 5.5 × 30 mm was inserted into the area of residual stenosis. Performed postdilation at pressures up to 12 atm. The balloon catheter has been removed. Control angiography showed residual stenosis in the stenting area of the left ICA 0%, intracranial arteries without signs of embolism (Fig. 6).

The distal embolism protection systems were alternately removed from the ICA and the main arteries. The tool has been removed. Manual hemostasis of the puncture area of the right common femoral artery. Aseptic and pressure dressings. Manual hemostasis of the puncture area of the right radial artery. Aseptic and pressure bandages.

The postoperative period was uneventful. ACVE did not recur. Conducted dual antplatelet therapy (acetylsalicylic acid 125 mg in the afternoon + clopidogrel 75 mg in the morning). The patient was discharged from the institution on the 10th day after the operation in a satisfactory condition.

Discussion

The first and only report in Russia devoted to reconstructive intervention on the carotid arteries in the presence of PEHA was the article by Shanitsyn I.N. The authors achieved a successful result of revascularization with the implementation of CEE [18]. However, it should be noted that in the presence of PEHA, the vertebral arteries are significantly hypoplastic, and the PCA is most often aplastic [18]. An open VC and a deficit of collateral circulation in the vertebrobasilar basin during clamping of the ICA during CEA can lead to the development of ischemic stroke in this area of the brain. This condition most often manifests itself in edema and herniation of the trunk with the development of a lethal outcome [25]. The only option to maintain the constancy of hemodynam-
ics during CEE is the installation of a temporary shunt (TS), which was described in the article by Shanitsyn I.N. But all "factory" samples of this device have only a 2-ended structure in order to start blood flow only from the CCA to the ICA [26–28]. In the situation with PEHA during CEE, it is necessary to resort to improvisational solutions, either by creating a new 3-terminal version of the TS, or by using 2 TS separately from CCA to ICA and separately from CCA to PEHA [18]. It should be noted that these manipulations will be characterized by a high complexity of implementation, and "piling up" in the wound along with tourniquets and vascular clamps of the TS branches will significantly reduce the visualization of the reconstruction zone and make it difficult to perform anastomosis [18]. An additional aggravating factor is reports that the insertion of a VS in carotid surgery itself may be accompanied by distal embolism, dissection, and thrombosis of the ICA due to balloon inflation [26–28]. And if in the case of a typical structure, due to the consistency of the TS, it is most often possible to achieve a regression of the neurological deficit at the hospital stage of observation, then in the situation with PEHA and the absence of PCA, the same distal embolism can occur in the main artery, which will be accompanied by risk of fatal complications [18]. Thus, the totality of the facts presented indicates that CEE is the least preferred option for brain revascularization in patients with hemodynamically significant stenosis of the A.N. Kazantsev artery and a functioning PEHA.
Fig. 3 – Angiography of the right subclavian and left vertebral arteries: 1—stenosis of the right vertebral artery 60% at the mouth.

Fig. 4 – (A) Angiography of the left subclavian and left vertebral arteries; 1—hypoplasia of the left vertebral artery; (B) Angiography of the left vertebral artery; 2—aplasia of the V4 segment of the left vertebral artery.
In this article, we have demonstrated an effective way to treat this complex cohort of patients in CAS. An important manipulation that made it possible to achieve a successful outcome of the treatment was the use of 2 traps placed separately in the ICA and in the PEHA from different arterial accesses. This approach made it possible to maximally selectively prevent distal embolism during stent placement, which became a key moment in achieving the optimal result of revascularization.

It should also be noted that the choice in favor of emergency CAS and the rejection of CEA was made in view of the analysis of the latest Russian multicenter study that demonstrated a protective mechanism for the prevention of hemorrhagic transformation when using endovascular methods for correcting hemodynamically significant ICA stenosis in the urgent mode [17].

In addition, I would like to justify the author’s name of the A.N. Kazantsev artery. Figure 1 shows that the diameter and dimensions of the PEHA are equivalent to the ICA. Thus, it is indisputable that PEHA is not correctly considered a branch of the ICA, it is an independent vessel. Based on this, the A.N. Kazantsev artery cannot be regarded as a segment of the ICA. It is also an independent vessel, the bifurcation of which forms PEHA and ICA. Thus, the A.N. Kazantsev artery must be considered an independent nomenclature unit of the brachiocephalic basin. Studies devoted to the results of studying the variant structures of the carotid bifurcation did not single out this arterial segment, considering it to be the ICA. However, based on the facts given above, it is impossible to consider the artery of A.N. Kazantsev ICA. It should also be noted that all known reports on the implementation of reconstructive interventions in such topographic conditions were carried out.

Fig. 5 – Angiography of the circle of Willis (open circle of Willis with the absence of both posterior connecting arteries):
1—left posterior cerebral artery; 2—the right posterior cerebral artery; 3—the right superior cerebellar artery; 4—the main artery; 5—middle cerebral artery; 6—internal carotid artery.
in a planned manner. And only in the last decade, surgeons have almost completely abandoned open operations (Table 1) on this arterial segment in favor of CAS (Table 2).

However, the authors did not describe the development of postoperative complications, demonstrating the efficacy and safety of both CAS and CEA.

It should be emphasized that in none of the above studies, the real artery was described as an independent formation. In addition, we analyzed 24 atlases of normal and pathological human topographic anatomy, in which this vascular formation was not distinguished into an independent artery either [41–63]. The authors described that the common carotid artery forms a bifurcation of the external carotid artery and the ICA, while the ICA goes to the skull without giving off branches [41–63]. The presence of PEHA has not been reported in these literature sources [41–63]. Thus, the segment of the artery corre-
sponding to this characteristic corresponds to the vessel that starts from the bifurcation of the A.N. Kazantsev artery and then goes to the carotid canal. And the artery of A.N. Kazantsev, as a previously undescribed vessel, can bear the names of the authors who singled it out as a separate nomenclature unit.

This clinical case, according to the data of domestic (www.elibrary.ru) and foreign (www.pubmed.gov) electronic libraries, is the first report of a successful emergency CAS of the A.N. Kazantsev artery in the presence of a functioning PEHA in the most acute period of stroke, which demonstrates high relevance and can be used in the practice of vascular surgeons, neurosurgeons, endovascular surgeons, neurologists.

### Conclusion

CAS of hemodynamically significant stenosis of the A.N. Kazantsev artery is a safe and effective method of cerebral revascularization in the most acute period of stroke.

### Patient consent

The patient signed a voluntary consent to the use of his data and information about the treatment provided under this article.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.radcr.2022.07.034.

### References

[1] Altman DA, Fokin AA, Vladimirsky VV, Baryshnikov AA, Ignatov VA, Chernousov VV, et al. Immediate results of reconstructive interventions on the carotid arteries in patients in the acute stage of ischemic stroke. Bull Chelyabinsk Region Clin Hosp 2018;2(40):40-4.

[2] Tsukurova LA, Timchenko LV, Golovko EN, Usachev AA, Fedorchenko AN, Porkhanov VA. Successful emergency surgical interventions on the brachiocephalic arteries in two patients in the acute period of ischemic stroke. Neurosurgery 2013(4):70-2.

[3] Dudanov IP, Belinskaya VG, Laptev KV, Vasilenko NO, Koblov ES, Sterlin OV. Reconstructive surgery on the carotid arteries in the complex treatment of acute ischemic stroke. Med Acad J 2011;11(2):109-16.

[4] Kazantsev AN, Vinogradov RA, Chernyavskyy MA, Kravchuk VN, Matusевич VV, Chernykh KP, et al. Multicenter study: carotid endarterectomy in the first hour after ischemic stroke. Rus J Cardiol 2021;26(6):76-80. doi:10.15829/1560-4071-2021-4316.

[5] Zakirzhano NR, Komarov RN, Khalilov IG, Bayazova NI, Evseeva VV. Comparative analysis of the safety of performing carotid endarterectomy in the most acute and acute periods of ischemic stroke. Angiol Vasc Surg 2021;27(1):97-106. doi:10.33529/ANGIO2021103.

[6] Vasilchenko NO, Rubleva OI, Verbitsky OP, Ordynets SV, Shabonov AA, Dudanov IP. Cerebral hyperperfusion syndrome after carotid endarterectomy in the acute period of ischemic stroke. Med Acad J 2017;17(4):17-21.

[7] Kazantsev AN, Chernykh KP, Zarkua NE, Leader RYu, Burkova E, Bagdavadze GSh, et al. Immediate and long-term results of carotid endarterectomy in different periods of ischemic stroke. Russian medical and biological bulletin named after academician L.P. Pavlova 2020;28(3):312–22. doi:10.23888/PAVLOV2020023312-322.

[8] Kazantsev AN, Chernykh KP, Leader RYu, Zarkua NE, Shabaev AR, Kubachev KG, et al. Emergency glomus-sparring carotid endarterectomy according to A.N. Kazantsev. Emerg Med Care 2020;9(4):494–503. doi:10.23934/2223-9022-2020-9-4-494-503.

[9] Kazantsev AN, Burkov NN, Tarasov RS, Anufriev AM, Shabaev AR, Ruban E, et al. Carotid endarterectomy in the acute period of ischemic stroke. Circc Pathol Cardiovasc Surg 2018;22(1):66-72. doi:10.21688/1681-3472-2018-1-66-72.

[10] Tarasov RS, Kazantsev AN, Moldavskaya IV, Burkov NN, Mironov AV, Lazukina IA, et al. Hospital results of carotid endarterectomy in the acute period of ischemic stroke: data from a single-center register. Cardiol Cardiovasc Surg 2018;11(5):60-5. doi:10.17116/kardio20181105160.

[11] Pokrovsky AV. National guidelines for the management of patients with diseases of the brachiocephalic arteries. Angiol Vasc Surg 2013;19(2):4-68.

[12] Kazantsev AN, Vinogradov RA, Chernyavskyy MA, Matusевич VV, Chernykh KP, Zakeryaev AB, et al. Urgent intervention of hemodynamically significant stenosis of the internal carotid artery in the acute period of ischemic stroke. Circc Pathol Cardiovasc Surg 2020;24(S):89-97. doi:10.21688/1681-3472-2020-35-89-97.
Kazantsev AN, Vinogradov RA, Kravchuk VN, Chernyavsky AM, Shabaev AR, Kachesov AV, et al. Concomitant symptomatic internal carotid artery stenosis associated with persistent primitive hypoglossal artery: case report and review of the literature. Minim Invasive Neurosurg 2009;52(5-6):263–6.

doi:10.1055/s-0029-1243243.

19. AkhmedOV, Bogovskova AV, Zotikov AE, Karpatyev NG, Chupin AV, Popov VA, et al. Results of various treatment strategies for patients with combined lesions of the internal carotid and coronary arteries. Endovasc Surg 2021;8(2):144–53. doi:10.2402/2409-4080-2021-8-2-144-153.

20. Akhurin RS, Shiryaeva AG, Galayutdinov DM, Vlasova EE, Vasiliev VP, Ismagilov BR, et al. Immediate results of combined operations of carotid endarterectomy and coronary revascularization in patients over 70 years of age with multifocal lesions of the brachiocephalic and coronary arteries. Bull NTSSSH 2019;20(2):135–40.

doi:10.24022/1810-0694.2019-20-2-135-140.

21. Alekryan BG, Bogovskov AV, Zotikov AE, Karpatyev NG, Chupin AV, Popov VA, et al. Results of various treatment strategies for patients with combined lesions of the internal carotid and coronary arteries. Endovasc Surg 2021;8(2):144–53. doi:10.2402/2409-4080-2021-8-2-144-153.

22. Akhurin RS, Shiryaeva AG, Galayutdinov DM, Vlasova EE, Vasiliev VP, Ismagilov BR, et al. Immediate results of combined operations of carotid endarterectomy and coronary revascularization in patients over 70 years of age with multifocal lesions of the brachiocephalic and coronary arteries. Bull NTSSSH 2019;20(2):135–40.

doi:10.24022/1810-0694.2019-20-2-135-140.

23. Akhurin RS, Shiryaeva AG, Galayutdinov DM, Vlasova EE, Vasiliev VP, Ismagilov BR, et al. Immediate results of combined operations of carotid endarterectomy and coronary revascularization in patients over 70 years of age with multifocal lesions of the brachiocephalic and coronary arteries. Bull NTSSSH 2019;20(2):135–40.

doi:10.24022/1810-0694.2019-20-2-135-140.

24. Sinelnikov RD. Atlas of human anatomy Textbook for students of medical universities: in 4 volumes. Volume The doctrine of blood vessels and lymphoid organs. Sinelnikov RD, Sinelnikov YaR, Sinelnikov YaA, editors. 7th ed; 2010. revised.
[40] Ryu B, Ishikawa T, Hashimoto K, Shimizu M, Yagi S, Shimizu T, et al. Internal carotid artery stenosis with persistent primitive hypoglossal artery treated with carotid artery stenting: a case report and literature review. Neuroradiol J 2016;29(2):115–21. doi:10.1177/197140915626427.

[41] Baybakov S.E., Vlasov E.A. Atlas of normal anatomy of magnetic resonance imaging and computed tomography of the brain. A textbook for medical students studying in the specialty 060101 "General Medicine" in the disciplines 03/14/01 "Human Anatomy", 01/14/13 "Radiation Diagnostics and Radiation Therapy" /St. Petersburg, 2015 https://elibrary.ru/item.asp?id=41207590.

[42] Anatomy according to Pirogov. Human anatomy atlas in 3 volumes /author-comp: Shilkin V.V., Filimonov V.I., Moscow, 2011 https://elibrary.ru/item.asp?id=19501525.

[43] Eliseev A.G. Popular atlas of human anatomy. Terms in 5 languages: Latin, Russian, English, French, German: the basics of anatomy in unique drawings A.G. Eliseev, N.A. Rossolovsky, eds. N. V. Ostrovsky. Moscow, 2009 https://elibrary.ru/item.asp?id=19500957.

[44] Samusev R.P., Sentyabrev N.N. Atlas of human anatomy and physiology. Textbook for institutions of secondary vocational education: the first domestic publication on anatomy and physiology, about 500 drawings. diagrams and tables, full compliance with the program on anatomy and physiology for institutions of secondary vocational education RP Samusev, NN Sentyubrev. Moscow, 2010 https://elibrary.ru/item.asp?id=19501412.

[45] Lyovkin SS. Human anatomy atlas Lyovkin Sergey Sergeyevich. Moscow; 2010. https://elibrary.ru/item.asp?id=19501834

[46] Semenov E.V. Atlas of human anatomy. Textbook for students of medical universities S.E.V., Elista, 2011. (2nd ed, revised and enlarged) https://elibrary.ru/item.asp?id=19503107.

[47] Fingers M.A., Ponomarev A.B., Berestova A.V. Atlas of pathological anatomy. Textbook for students of medical universities M. A. Paltsev, A. B. Ponomarev, A. V. Berestova. Moscow, 2007. Ser. Educational Literature for Students of Medical Universities (3rd ed) https://elibrary.ru/item.asp?id=19539075.

[48] Sapin M.R. Atlas of normal human anatomy study. Manual for students of medicine. Universities: in 2 volumes /M.R.Sapin, D. B. Nikityuk, E. V. Shvetsov. Moscow, 2006. Vol. T: 2 (2nd ed.) https://elibrary.ru/item.asp?id=19492623.

[49] Sinelnikov R.D., Sinelnikov Y.R., Sinelnikov A.Ya. Atlas of human anatomy in 4 volumes: a textbook for students of medical universities R.D. Sinelnikov, Ya.R. Sinelnikov, A.Ya. Sinelnikov. Moscow, 2007. ([7th ed., Revised]) https://elibrary.ru/item.asp?id=19494803.

[50] Bilich G.L., Nikolenko V.N. Atlas of human anatomy. volume 1. Study guide /Rostov-on-Don, 2014 https://elibrary.ru/item.asp?id=29349288.

[51] Kolsanov AV, Ruban EO. Three-dimensional atlas of normal and pathological anatomy of the human body; 2015. Certificate of registration of the computer program RU 2015614329, 15.04 Application No. 2015611365 dated February 26, 2015. https://elibrary.ru/item.asp?id=39330376

[52] Sokolova IO, Belyakov DA. 3D atlas of anatomy and physiology of the human cardiovascular system in health and disease; 2016. Certificate of registration of the computer program RU 2016613502, 28.03 Application No. 2016611076 dated 02/09/2016. https://elibrary.ru/item.asp?id=39945690

[53] Malafeeva SN, Pavlova IV. Atlas on human anatomy and physiology. Yekaterinburg; 1999 https://elibrary.ru/item.asp?id=36997362

[54] Smirnov AV. Atlas of private pathological anatomy. Electronic study guide. Volgograd; 2016. https://elibrary.ru/item.asp?id=28970189

[55] Textbook /Edited by Borzyak EI, Gunther FKh, Putilova IN. Human anatomy Photographic atlas. Volume 2 Cardiovascular system. Borzyaka EI, editor The lymphatic system, Moscow; 2015. https://elibrary.ru/item.asp?id=25079490

[56] Konovalov AN, Blinkov SM, Putsilov MV. Atlas of neurosurgical anatomy. Moscow; 1990. https://elibrary.ru/item.asp?id=20147621

[57] Akinfiev D.M., Bartosh N.O., Bobrov B.Yu., Volynsky Yu.D., Garbuзов R.V., Goncharov A.I., et al. Atlas of comparative X-ray surgical anatomy textbook for the system of postgraduate professional education of doctors /Moscow, 2012 https://elibrary.ru/item.asp?id=19562553.

[58] Balakhonova T.V., Gorokhova S.G., Saidova M.V., Smolyaninova N.G., Aleksandrova-Tebenkova E.S., Arakelyants A.A., et al. Ultrasound examination of the heart and blood vessels. Practical guide /Moscow, 2015. (2nd ed, supplemented and expanded) https://elibrary.ru/item.asp?id=24136130.

[59] Schwartzman G, Ramamurti P. Visible body human anatomy atlas: innovative anatomy learning. J Digit Imaging 2021;34(5):1228–30 Oct. doi:10.1007/s10278-021-00496-5.

[60] Mercadante AA, Raja A. Anatomy, arteries. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.

[61] Tucker WD, Arora Y, Mahajan K. Anatomy, blood vessels. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.

[62] Matienzo D, Bordoni B. Anatomy, blood flow. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.

[63] Balamal OA, Soos MP. Anatomy, thorax, heart great vessels. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.