DOI: https://doi.org/10.17816/DD108404

Возможности диагностики: инновационный подход в использовании магнитно-резонансной томографии при аневризме аорты

Е. Кобелев[1], Н.Т. Пак[1], Е.Э. Бобрикова[1], В.Ю. Усов[2], Е.Э. Кливер[1], Д.А. Сирота[1], А.М. Чернявский[1], Т.А. Берген[1]

[1] Национальный медицинский исследовательский центр имени академика Е.Н. Мешалкина, Новосибирск, Российская Федерация
[2] Томский национальный исследовательский медицинский центр, Томск, Российская Федерация

АННОТАЦИЯ

В статье сообщается об инновационном применении магнитно-резонансной томографии для определения хирургической тактики.

Авторы описывают случай 47-летнего пациента, которому провели исследование методом магнитно-резонансной томографии с последующим хирургическим лечением аневризмы аорты. В отличие от эхокардиографии, этот способ диагностики позволяет увидеть всю грудную аорту, в отличие от компьютерной томографии — помогает выявить изменения в стенке аорты. С помощью магнитно-резонансной томографии удалось определить дистальный край резекции. Послеоперационный период прошёл без осложнений. По синхронизированным с электрокардиограммой данным проведена оценка структурных изменений стенки аорты и её механические свойства. Важно отметить, что результаты магнитно-резонансной томографии коррелировали с результатами гистологического исследования.

Для эффективного хирургического лечения пациентов с аневризмой аорты необходимо определять степень изменений в стенке сосуда.

Магнитно-резонансная томография стенки аорты — перспективное направление в диагностике, требующее дальнейшего изучения в многоцентровых исследованиях.

Ключевые слова: МРТ; магнитно-резонансная томография; аневризма грудной аорты; стенка аорты; клинический случай.

Как цитировать

Кобелев Е., Пак Н.Т., Бобрикова Е.Э., Усов В.Ю., Кливер Е.Э., Сирота Д.А., Чернявский А.М., Берген Т.А. Возможности диагностики: инновационный подход в использовании магнитно-резонансной томографии при аневризме аорты // *Digital Diagnostics.* 2022. Т. 3, № 3. С. 332–339. DOI: https://doi.org/10.17816/DD108404

Рукопись получена: 31.05.2022 **Рукопись одобрена:** 29.06.2022 **Опубликована:** 22.08.2022

DOI: https://doi.org/10.17816/DD108404

Diagnostic challenge: innovative approach in use of magnetic resonance imaging in aortic aneurysm

Evgenii Kobelev[1], Natalya T. Pak[1], Evgeniya E. Bobrikova[1], Wladimir Yu. Usov[2], Evgeniy E. Kliver[1], Dmitriy A. Sirota[1], Aleksandr M. Chernyavskiy[1], Tatyana A. Bergen[1]

[1] E. Meshalkin National Medical Research Center, Novosibirsk, Russian Federation
[2] Tomsk National Research Medical Center, Tomsk, Russian Federation

ABSTRACT

Here we report a case of technological innovation: the use of magnetic resonance imaging to determine surgical strategy.

Here is a 47-year-old man who underwent an magnetic resonance imaging and subsequent surgical treatment of the aortic aneurysm. Unlike echocardiography, magnetic resonance imaging enabled us to view the entire thoracic aorta. Unlike computer tomography, magnetic resonance imaging enabled us to detect changes in the aortic wall accurately. Thus, in this case, the use of magnetic resonance imaging allowed us to determine the distal resection edge. The patient`s postoperative course was unremarkable. Use of electrocardiogram-synchronized magnetic resonance imaging of thoracic aorta allows detecting structural changes of the aortic wall and its mechanical properties. It is significant that magnetic resonance imaging results of the aortic wall correlate with histologic examination.

The extent of changes in the aortic wall must be determined to accurately plan surgical treatment of patients with aortic aneurism.

Magnetic resonance imaging of the aortic wall is promising for further study in multicenter research.

Keywords: MRI; magnetic resonance imaging; thoracic aneurism; aortic wall; case report.

To cite this article

Kobelev E, Pak NT, Bobrikova EE, Usov WYu, Kliver EE, Sirota DA, Chernyavskiy AM, Bergen TA. Diagnostic challenge: innovative approach in use of magnetic resonance imaging in aortic aneurysm. *Digital Diagnostics.* 2022;3(3):332–339. DOI: https://doi.org/10.17816/DD108404

Received: 31.05.2022 **Accepted:** 29.06.2022 **Published:** 22.08.2022

DOI: https://doi.org/10.17816/DD108404

诊断能力：在主动脉瘤中使用磁共振成像的创新方法

Evgenii Kobelev[1], Natalya T. Pak[1], Evgeniya E. Bobrikova[1], Wladimir Yu. Usov[2], Evgeniy E. Kliver[1], Dmitriy A. Sirota[1], Aleksandr M. Chernyavskiy[1], Tatyana A. Bergen[1]

[1] E. Meshalkin National Medical Research Center, Novosibirsk, Russian Federation
[2] Tomsk National Research Medical Center, Tomsk, Russian Federation

简评

本文介绍了磁共振成像在确定手术策略方面的创新应用。

作者描述了一名47岁患者的病例，该患者接受了磁共振成像，随后对主动脉瘤进行了手术治疗。与超声心动图不同，此类诊断方法可以看到整个胸主动脉，与计算机断层扫描不同，它有助于识别主动脉壁的变化。使用磁共振成像，我们能够确定切除的远心端。术后期间一切顺利。根据与心电图同步的数据，我们评估了主动脉壁的结构变化及其力学性能。值得注意的是，磁共振成像的结果与组织学检查的结果相关。

为了对主动脉瘤患者进行有效的手术治疗，必须确定血管壁的变化程度。

主动脉壁的磁共振成像是一个很有前途的诊断方向，需要在多中心研究中进一步研究。

关键词：MRI； 磁共振成像； 胸主动脉瘤； 主动脉壁； 临床病例。

To cite this article
Kobelev E, Pak NT, Bobrikova EE, Usov WYu, Kliver EE, Sirota DA, Chernyavskiy AM, Bergen TA. 诊断能力：在主动脉瘤中使用磁共振成像的创新方法. *Digital Diagnostics.* 2022;3(3):332–339. DOI: https://doi.org/10.17816/DD108404

收到： 31.05.2022 **接受：** 29.06.2022 **发布日期：** 22.08.2022

RELEVANCE

Patients with a thoracic aneurysm should be evaluated for prompt surgical intervention unless life expectancy from comorbid conditions is limited or quality of life is substantially impaired [1]. According to the most recent guidelines, the examination includes computed tomographic imaging or magnetic resonance imaging only for diameter measurements [2–4]. Here we report a new and unique MRI application to use in patients with a thoracic aneurism, which affects surgical strategy choice.

CASE REPORT

Here is a 47-year-old man who underwent an MRI and subsequent surgical treatment of an aortic aneurysm. The patient has no aggravating factors or chronic disease in the anamnesis.

Ascending aortic aneurysms is always a challenge for physicians. In the examination, echocardiography revealed dilatation of the ascending aorta up to 5.5 cm without aortic regurgitation.

The patient underwent an electrocardiogram (ECG)-synchronized MRI of the aorta and cardiac MRI. The study was performed on MRI 1.5T with a cardiac coil.

We used T2, T1 weighted scans without, and then with T1 weighted scan contrast enhancement. During MRI, was performed contrast enhancement angiography (Figure 1). The maximum diameter of the ascending aorta was 5.4 cm, the distance between proximal and caudal aneurismal edge was 9 cm. The diameter of the aorta before the orifice of the brachiocephalic trunk was up to 3.4 cm, between the orifices of the left common carotid and subclavian arteries — up to 2.4 cm, in the descending part — up to 2.3 cm. The distance from the edge of the brachiocephalic trunk to the cranial aneurismal edge was 5.5cm.

As part of the study, sequences for aortic wall examination were performed.

To assess the aortic wall's elasticity and contractility, we used native steady-state free-precession (SSFP) scans in the axial and coronary planes (Figure 1).

In the cine-SSFP view, we were able to clearly visualize the aortic wall's movement during the cardio cycle and blood flow direction. The QFlow sequence can be used to quantify the pulse wave velocity in an aneurysm or if aortic valve function is required. To examine the ascending aorta wall's thickness and vascularization, T1-spin-echo and gradient-echo in the axial plane, T1-spectrally selective suppression sequence and Spectral Presaturation with Inversion Recovery (SPIR) Black-Blood (BB) MRI (Fig. 2), T2-spectrally suppression sequence, and Black-Blood in the axial and oblique planes were performed.

According to the MRI conclusion, the patient has an enlarged ascending aorta from the root for up to 9 cm, with a

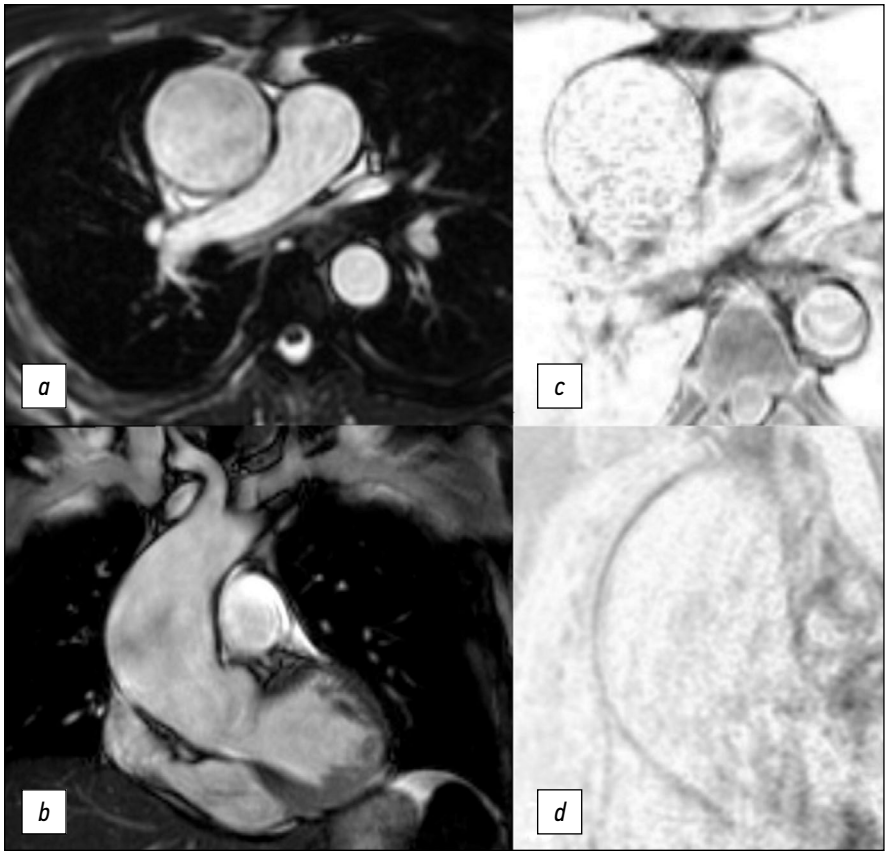

Fig. 1. Steady-state free-precession (SSFP) imaging oriented axially (*a*) and coronal (*b*), T1-SE (*c*) axially (in the middle third of the aortic aneurysm) and T1-SPIR-black blood (*d*) in the oblique plane. Thinned aortic wall, more defined in the middle part.

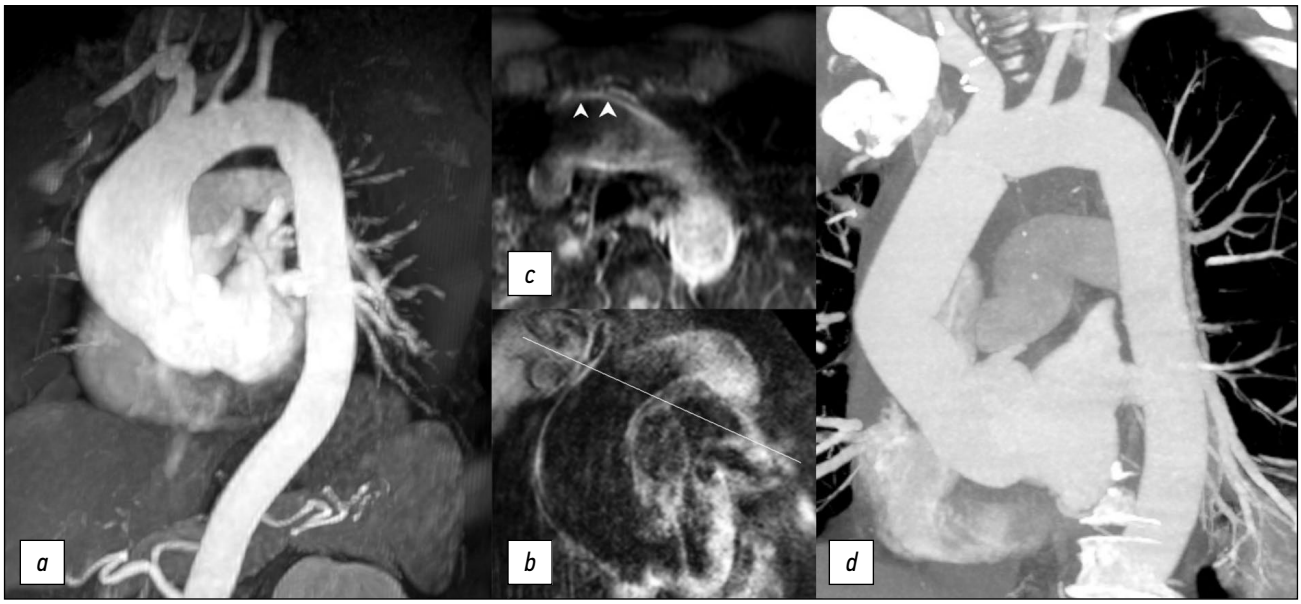

Fig. 2. MR-contrast enhancement angiography, arterial phase, in breath-hold, in the oblique plane, 3D reconstruction of the aorta (*a*), T1-SPIR-BB imaging, axial plane (*b*) immediately after distal aneurysm edge of ascending aorta; oblique plane (*c*) before orifice of the brachiocephalic trunk. The intact thickness of the aortic wall (arrows), CT angiography of the thoracic aorta after surgical treatment (*d*).

maximum diameter of up to 5.5 cm. According to the modern guidelines a patient needs surgical treatment. The wall in the aneurysm is evenly thinned, more defined in the middle part, the pulsation is reduced, with signs of dyskinesia, from the edge of the aneurysm to the orifice of the brachiocephalic trunk – the aortic wall is intact (Figure 2) within no more than 3 cm, the aortic diameter at this level is no more than 3.5 cm. Additionally, the patient has a bicuspid aortic valve [1, 2, 4]. Dissection, thickening, and hypervascularization of the thoracic aorta wall and the proximal parts of its main branches were not revealed. The orifice of the main branches was typical anatomy.

DISCUSSION

Initially, during the existing strategy, it was planned to apply a clamp directly in front of the brachiocephalic trunk's orifice, but, taking into account the MRI data, the surgical approach was adjusted. Considering the spread of the lesion of the aortic wall to the arcus distal to the aneurysm, it was decided to perform the intervention under conditions of circulatory arrest and antegrade unilateral cerebral perfusion. It is important that in case of resection and the pathology altered aortic wall, complications can be expected in the early and the late postoperative period. In this case, the patient underwent supracoronary prosthesis of the ascending part and the aortic arch with the formation of a distal anastomosis of the "half-arc" type.

After surgical treatment, a computer tomogram (CT) angiography of the thoracic aorta was performed (Figure 2). On postoperative scans, the diameter of the contrasting lumen of the aorta was not expanded. There were no endoleaks.

When comparing the MRI data with the histological examination results of intraoperative biopsy (resected aortic wall), the correspondence of the revealed changes in the aortic wall was noted. Macroscopically, the resected aorta's wall thickness was found in distal and proximal edge 2.0-3.0 mm, in the middle part (including part of the distal aneurismal edge) 1.0-1.5 mm.

Microscopically, in sections from the proximal and distal parts of the aortic aneurysm and 2 cm from the distal resection edge: widespread destruction in the middle layer, mucoid swelling of elastic fibers, smoothing of the folds of elastic membranes were found. In some areas, closer to the adventitia, there are moderate scattered perivascular lymphoid infiltrations, part of the aortic wall's vessels with obliteration of the lumens. Under the intima, there are focal accumulations of macrophages with foamy cytoplasm not protruding above the surface. (Fig. 3).

Histopathological diagnosis: nonspecific secondary vasculitis of low activity, degradation of the aorta's elastic membranes' middle layer. Aneurysm of the ascending aorta. Atherosclerosis of the aorta, stage of lipid spots.

CONCLUSION

Unlike CT, MRI enables examining the structure and mechanical properties of an aortal wall and measurement of the diameter. In this case, an aortic wall MRI examination made it possible to choose the optimal surgical approach.

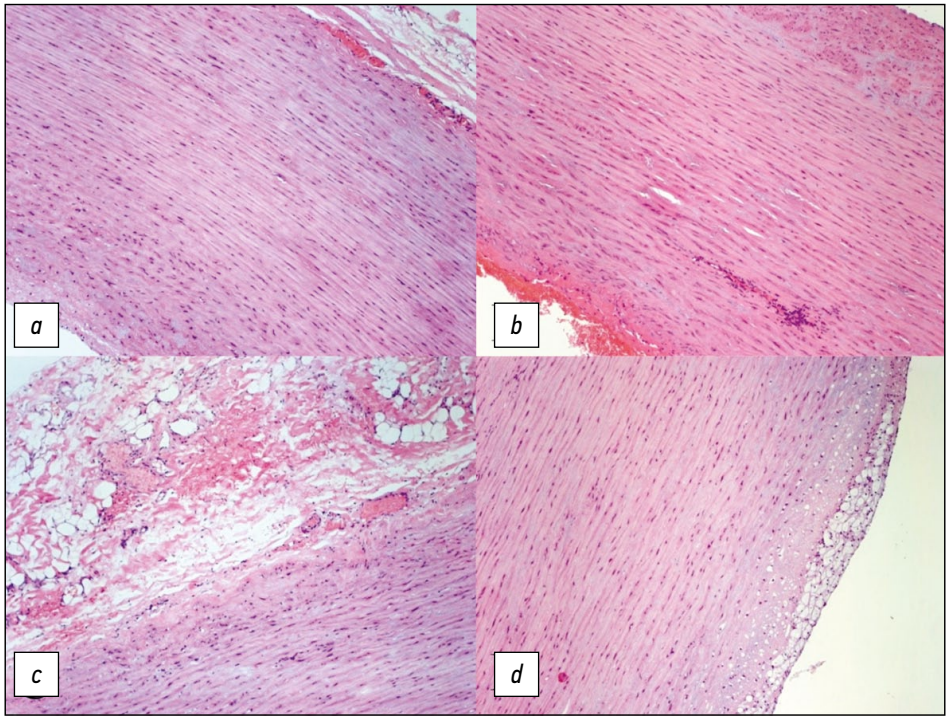

Fig. 3. Proximal (*a*, *b*) and medium (*c*) part of aneurism. Destruction, mucoid swelling elastic fibers, smoothing folds of elastic membranes. Scattered perivascular lymphoid infiltrates. Distal (*d*) part of the resected aortic wall. Destruction, mucoid swelling elastic fibers, smoothing folds of elastic membranes.

ADDITIONAL INFORMATION

Funding source. The work was carried out within the state assignment of the Ministry of Health of the Russian Federation (Development of tissue-engineered structures for cardiovascular surgery; N 121032300337-5).

Competing interests. The authors declare no conflict of interest.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work. T.A. Bergen, D.A. Sirota — conception and design of the work; E. Kobelev, N.T. Pak, E.E. Kliver — acquisition, analysis of data; E.E. Bobrikova, V.Yu. Usov — interpretation of data; A.M. Chernyavskiy — approved the final version of the work.

Consent for publication. Written consent was obtained from the patient for publication of relevant medical information and all of accompanying images within the manuscript in Digital Diagnostics journal.

Acknowledgments. We thank the Chief of the Institution of Experimental Biology and Medicine "E. Meshalkin National Medical Research Center" of the Ministry of Health of the Russian Federation MD Ph.D. professor Irina Yu. Zhuravleva for the opportunity to carry out this work.

REFERENCES

1. Erbel R, Aboyans V, Boileau C. et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The task force for the diagnosis and treatment of aortic diseases of the European society of cardiology (ESC). *Eur Heart J*. 2014;35(41):2873–926. doi: 10.1093/eurheartj/ehu281

2. Hiratzka LF, Bakris GL, Beckman JA, et al. Guidelines for the diagnosis and management of patients with thoracic aortic disease. A report of the American College of Cardiology Foundation/ American Heart Association Task Force on Practice Guidelines, American Association for Thoracic Surgery, American College of Radiology, American Stroke Association, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of Thoracic Surgeons, and Society for Vascular Medicine. *J Am Coll Cardiol*. 2010;55(14):e27–e129.

3. Galizia MS, Bolen MA, Flamm S. MRI of the thoracic aorta. *Applied Radiology*. 2015;44(8):22–26. doi: 10.37549/ar2207

4. Saliba E, Sia Y. The ascending aortic aneurysm: When to intervene? *IJC Heart Vasculature*. 2015;6:91–100. doi: 10.1016/j.ijcha.2015.01.009

СПИСОК ЛИТЕРАТУРЫ

1. Erbel R., Aboyans V., Boileau C., et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC) // Eur Heart J. 2014. Vol. 35, N 41. P. 2873–2926. doi: 10.1093/eurheartj/ehu281

2. Hiratzka L.F., Bakris G.L., Beckman J.A., et al. Guidelines for the diagnosis and management of patients with thoracic aortic disease. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, American Association for Thoracic Surgery, American College of Radiology, American Stroke Association, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, Society of Thoracic Surgeons, and Society for Vascular Medicine // J Am Coll Cardiol. 2010. Vol. 55, N 14. P. e27–e129.

3. Galizia M.S., Bolen M.A., Flamm S. MRI of the thoracic aorta // Applied Radiology. 2015. N 44, N 8. P. 22–26. doi: 10.37549/ar2207

4. Saliba E., Sia Y. The ascending aortic aneurysm: when to intervene? // IJC Heart Vasculature. 2015. Vol. 6. P. 91–100. doi: 10.1016/j.ijcha.2015.01.009

AUTHORS' INFO

Tatyana A. Bergen, MD, Dr. Sci. (Med.);
address: 15, Rechkunovskaya str., Novosibirsk, 630055, Russia;
ORCID: http://orcid.org/0000-0003-1530-1327;
eLibrary SPIN: 5467-7347; e-mail: bergen_t@meshalkin.ru

Eugenii Kobelev;
ORCID: http://orcid.org/0000-0002-5901-2271;
eLibrary SPIN: 7828-9713; e-mail: kobelev_e@meshalkin.ru

Natalya T. Pak, MD, Cand. Sci. (Med.);
ORCID: http://orcid.org/0000-0002-7842-9881;
eLibrary SPIN: 1896-8447; e-mail: n_pak@meshalkin.ru

Evgeniya E. Bobrikova;
ORCID: http://orcid.org/0000-0001-5985-4076;
eLibrary SPIN: 6315-9772; e-mail: bobrikova_e@meshalkin.ru

Wladimir Yu. Ussov, MD, Dr. Sci. (Med.), Professor;
ORCID: http://orcid.org/0000-0001-7978-5514;
eLibrary SPIN: 1299-2074; e-mail: ussov1962@yandex.ru

Evgeniy E. Kliver, MD, Dr. Sci. (Med.);
ORCID: http://orcid.org/0000-0002-3915-3616;
eLibrary SPIN: 1511-3814; e-mail: ee_kliver@meshalkin.ru

Dmitriy A. Sirota, MD, Cand. Sci. (Med.);
ORCID: http://orcid.org/0000-0002-9940-3541;
eLibrary SPIN: 4706-7549; e-mail: d_sirota@meshalkin.ru

Aleksandr M. Chernyavskiy, MD, Dr. Sci. (Med.), Professor, Corresponding member of the Russian Academy of Sciences;
ORCID: http://orcid.org/0000-0001-9818-8678;
eLibrary SPIN: 5286-6950;
e-mail: a_cherniavsky@meshalkin.ru

ОБ АВТОРАХ

*** Берген Татьяна Андреевна,** д.м.н.;
адрес: Россия, 630055, Новосибирск, ул. Речкуновская, д. 15;
ORCID: http://orcid.org/0000-0003-1530-1327;
eLibrary SPIN: 5467-7347; e-mail: bergen_t@meshalkin.ru

Кобелев Евгений;
ORCID: http://orcid.org/0000-0002-5901-2271;
eLibrary SPIN: 7828-9713; e-mail: kobelev_e@meshalkin.ru

Пак Наталья Тихоновна, к.м.н.;
ORCID: http://orcid.org/0000-0002-7842-9881;
eLibrary SPIN: 1896-8447; e-mail: n_pak@meshalkin.ru

Бобрикова Евгения Эдуардовна;
ORCID: http://orcid.org/0000-0001-5985-4076;
eLibrary SPIN: 6315-9772; e-mail: bobrikova_e@meshalkin.ru

Усов Владимир Юрьевич, д.м.н., профессор;
ORCID: http://orcid.org/0000-0001-7978-5514;
eLibrary SPIN: 1299-2074; e-mail: ussov1962@yandex.ru

Кливер Евгений Эдуардович, д.м.н.;
ORCID: http://orcid.org/0000-0002-3915-3616;
eLibrary SPIN: 1511-3814; e-mail: ee_kliver@meshalkin.ru

Сирота Дмитрий Андреевич, к.м.н.;
ORCID: http://orcid.org/0000-0002-9940-3541;
eLibrary SPIN: 4706-7549; e-mail: d_sirota@meshalkin.ru

Чернявский Александр Михайлович, д.м.н., профессор, член-корр. РАН;
ORCID: http://orcid.org/0000-0001-9818-8678;
eLibrary SPIN: 5286-6950;
e-mail: a_cherniavsky@meshalkin.ru

* Corresponding author / Автор, ответственный за переписку