

Surgical treatment of vascular rings in children: from early symptom relief to evidence-based individualized management

Alexey V. Voitov

Corresponding author: Alexey V. Voitov,
alex99.88@mail.ru

Received 13 October 2026. Revised 14 October 2026. Accepted 15 October 2026.

How to cite: Voitov A.V. Surgical treatment of vascular rings in children: from early symptom relief to evidence-based individualized management. *Patologiya krovoobrashcheniya i kardiokirurgiya = Circulation Pathology and Cardiac Surgery*. 2026;30(3):88-93
<https://doi.org/10.21688/1681-3472-2026-3-88-93>

Funding

The study did not have sponsorship.

ORCID

A.V. Voitov,
<https://orcid.org/0000-0003-3797-4899>

© 2026 Voitov



Meshalkin National Medical Research Center, Novosibirsk, Russian Federation

Abstract

Introduction: Vascular rings are a clinically heterogeneous group of congenital vascular anomalies that compress the airways and esophagus. They are reported to account for 1.08–2.09% of all diagnosed congenital heart defects. Better diagnostic imaging has led to more asymptomatic cases being found. However, indications for preventive intervention, the optimal timing of repair and the extent of surgery needed are still debated. The study by Bedin et al. provides Russian data relevant to these questions.

Objective: To discuss the early surgical outcomes of vascular ring repair reported by Bedin et al. in the context of current literature. The focus is on diagnostic assessment, choice of surgical strategy, postoperative complications and the limits of the available evidence.

Results: Among 58 operated children, all symptoms had resolved by discharge in 83.7% of patients who had symptoms before surgery, and there were no deaths. These findings show favorable early outcomes but do not establish whether early surgery is more effective than surveillance. Current literature stresses the need to distinguish fixed vascular compression from dynamic airway collapse. Data from 2025 support further study of Kommerell diverticulum plication and/or pexy but do not show that these techniques are equivalent to diverticulum resection. The incidence of chylothorax was 22.4% in the study by Bedin et al., compared with 13.2% in a 2026 multicenter study. This difference calls for analysis of patient populations, diagnostic criteria and surgical factors. Standardized stenosis measurement, swallowing assessment and the distinction between anatomical decompression and functional recovery also need attention.

Conclusion: Surgical repair of vascular rings in infants and young children gives favorable early outcomes. However, indications for intervention in asymptomatic patients, the optimal timing of surgery and the choice of additional surgical techniques need further evidence. Individualized treatment should take into account vascular anatomy, the severity of compression and how well the airways and esophagus function. Multicenter prospective studies with standardized assessment of long-term outcomes are needed to refine treatment strategy and prevent complications.

Keywords: aortopexy; chylothorax; Kommerell diverticulum; surgical outcomes; tracheal compression; tracheobronchomalacia; vascular ring

Хирургическое лечение сосудистых колец у детей: от раннего устранения симптомов к персонифицированному подходу

А.В. Войтов

Для корреспонденции: Алексей Викторович Войтов, alex99.88@mail.ru

Поступила в редакцию 13 октября 2026 г.
Исправлена 14 октября 2026 г.

Федеральное государственное бюджетное учреждение «Национальный медицинский исследовательский центр имени академика Е.Н. Мешалкина» Министерства здравоохранения Российской Федерации, Новосибирск, Российская Федерация

Принята к печати 15 октября 2026 г.

Цитировать: Войтов А.В. Хирургическое лечение сосудистых колец у детей: от раннего устранения симптомов к персонализированному подходу. *Патология кровообращения и кардиохирургия*. 2026;30(3):88-93 <https://doi.org/10.21688/1681-3472-2026-3-88-93>

Финансирование

Исследование не имело спонсорской поддержки.

ORCID

А.В. Войтов,
<https://orcid.org/0000-0003-3797-4899>

© Войтов А.В., 2026



Аннотация

Актуальность. Сосудистые кольца представляют собой клинически неоднородную группу врожденных сосудистых аномалий, вызывающих компрессию дыхательных путей и пищевода. Указанный для настоящей дискуссии диапазон их распространенности составляет 1,08–2,09 % всех диагностированных врожденных пороков сердца. Совершенствование диагностики расширяет выявление бессимптомных форм, однако показания к профилактическому вмешательству, оптимальные сроки коррекции и необходимый объем операции остаются предметом обсуждения. Исследование Бедина А.В. и соавт. представляет отечественные данные, значимые для оценки этих вопросов.

Цель. Обсудить непосредственные результаты хирургического лечения сосудистых колец, представленные Бединым А.В. и соавт., в контексте современных публикаций, уделяя внимание диагностике, выбору хирургической тактики, послеоперационным осложнениям и ограничениям доказательной базы.

Результаты. В исследовании указано 58 оперированных детей, полный регресс симптомов к выписке зарегистрирован у 83,7 % исходно симптомных пациентов; летальных исходов не было. Эти наблюдения свидетельствуют о благоприятных непосредственных результатах, но не определяют сравнительную эффективность ранней операции и наблюдения. Современная литература подчеркивает необходимость разграничения фиксированной сосудистой компрессии и динамического коллапса дыхательных путей. Данные 2025 г. поддерживают дальнейшее изучение пликаций и/или фиксации дивертикула Коммереля, однако не доказывают их равноценность его резекции. Частота хилоторакса в работе Бедина А.В. и соавт. составила 22,4 %, тогда как в многоцентровом исследовании 2026 г. – 13,2 %. Различия требуют анализа состава пациентов, диагностических критериев и хирургических особенностей. Отдельного внимания заслуживают стандартизация измерения стеноза, оценка глотания и разграничение анатомической декомпрессии и функционального восстановления.

Заключение. Хирургическая коррекция сосудистых колец у младенцев и детей раннего возраста обеспечивает благоприятные непосредственные результаты. Вместе с тем показания к вмешательству у бессимптомных пациентов, оптимальные сроки операции и выбор дополнительных хирургических приемов требуют дальнейшего обоснования. Индивидуализация лечения должна учитывать сосудистую анатомию, выраженность компрессии и функциональное состояние дыхательных путей и пищевода. Для уточнения лечебной тактики и профилактики осложнений необходимы многоцентровые проспективные исследования со стандартизированной оценкой отдаленных исходов.

Ключевые слова: аортопексия; дивертикул Коммереля; компрессия трахеи; сосудистое кольцо; трахеобронхомалия; хилоторакс; хирургические исходы

Introduction

Vascular rings hold a special place among congenital cardiovascular anomalies. Their clinical significance comes mainly from compression of the airways and esophagus, not from impaired intracardiac hemodynamics. As a result, the diagnostic pathway often begins with a pulmonologist, otorhinolaryngologist or gastroenterologist [1]. Because

stridor, cough and feeding difficulties are nonspecific, the vascular cause of the disease is often recognized late.

Vascular rings account for 1.08–2.09% of all diagnosed congenital heart defects [2; 3]. A share of diagnosed defects is not the same as an incidence among live births. For example, Chiu et al. report about 1–1.3 cases of complete vascular rings per 10,000 live births [4].

These figures cannot be compared directly because their denominators and the range of anomalies they include are different.

The study by Bedin et al. included 58 children operated on at a single center between 2018 and 2024 [5]. It matters not only for the early outcomes it reports. It also gives an opportunity to discuss three key questions: who should have surgery, how extensive the intervention should be, and which outcomes count as evidence that it works.

Discussion

Diagnosis: anatomy is no substitute for functional assessment

A strength of the study is that all patients underwent contrast-enhanced multislice computed tomography. This imaging shows the vascular anatomy, the site of compression and the details needed for surgical planning. However, anatomical imaging does not fully describe how the airways function.

In their review, Chiu et al. regard computed tomography or magnetic resonance angiography as essential for defining spatial relationships. They consider dynamic tracheobronchoscopy the main method for assessing tracheobronchomalacia [4]. Fixed narrowing must be distinguished from dynamic collapse, because relieving vascular compression does not always restore tracheal wall stability right away.

In the study by Bedin et al., bronchoscopy was performed in 46 patients, but dynamic collapse was not described with a single quantitative measure [5]. Future analyses should use a standard way to describe the location, length and mechanism of narrowing. Dysphagia needs the same approach, since vascular compression, impaired motility and aspiration each call for a different diagnostic interpretation.

Conventional methods (echocardiography, CT angiography, magnetic resonance imaging and bronchoscopy) remain the basis of diagnosis. However, complex spatial anatomy can make them hard to interpret. 3D reconstruction and physical 3D-printed models make preoperative planning considerably more accurate. They show precisely how the vessels, trachea and esophagus relate to each other in space, which is especially important in atypical variants. They also allow surgeons to plan and rehearse the operative steps on a model, choose the best approach and foresee technical difficulties. This may shorten operative time and reduce intraoperative complications [6; 7].

Asymptomatic patients: the safety of surgery does not prove its necessity

In asymptomatic children, the authors used tracheal deviation, or narrowing of the trachea or a main bronchus by 20% or more, as indications for intervention [5]. This approach aims to prevent the consequences of compression, but it needs independent validation. It is true that the absence of symptoms does not rule out structural changes. At the same time, the degree of narrowing depends on how it is measured. It should be stated whether lumen diameter or cross-sectional area is measured, which segment serves as the reference and whether the respiratory phase is taken into account. Without these details, the same percentage may describe different conditions.

In a 2024 study, Ajdaa et al. reported their experience managing 82 patients, including asymptomatic children [8]. The study supports safe surgical repair in selected cases. However, its retrospective design cannot show that preventive surgery is better than surveillance. What matters clinically is therefore not the presence of a ring as such, but the combination of anatomy, functional impairment and the course of the condition. Whether surgery is needed should be decided separately from whether it is technically feasible.

The meta-analysis by Rato et al. produced comparable results. There were no postoperative deaths, the complication rate was low at 15%, and the reintervention rate was 2%. It is important to note, however, that symptoms such as stridor or dysphagia may persist during the first year even after the ring has been successfully divided. This is often not caused by the operation itself. More often, long-standing compression before surgery has led to structural airway changes, such as tracheobronchomalacia or stenosis [9].

Optimal age: the hypothesis of early repair requires comparative data

The median age at surgery in the study by Bedin et al. was 7 months [5]. The proposal to operate before 1 year of age has a pathophysiological basis: ending compression may limit secondary airway changes. However, the authors state explicitly that they could not confirm an effect of age on symptom resolution in their cohort.

Favorable results after early intervention therefore do not establish a universal age threshold. The optimal timing may differ between double aortic arch, right aortic arch with ligamentum arteriosum and pulmonary artery sling.

In pulmonary artery sling, baseline stenosis and associated tracheal disease are especially important. In the study, all four patients in this group still had respiratory problems after repair, and one needed slide tracheoplasty [5]. These findings show the need for a strategy tailored to each patient's anatomy and function rather than a single age-based rule.

The findings of Bedin et al. are consistent with those of Swarnkar et al., who showed that early diagnosis and repair before irreversible changes develop lead to a better long-term prognosis. In that study, late surgical repair was the only statistically significant predictor of postoperative complications. Residual symptoms at 1 year after surgery were also less common in patients who were diagnosed earliest [10].

Kommerell diverticulum: relief of compression or extended reconstruction?

Aortopexy was performed in 29 patients in the cohort, including 24 children with a right aortic arch and a left ligamentum arteriosum [5]. However, how often a procedure is used does not prove that it is effective. Here, it was chosen on anatomical grounds rather than assigned at random.

Recent data make this discussion more concrete. In 2025, Perkins et al. compared 44 patients: 22 underwent division of the ligament alone, and another 22 also had plication and/or pexy of the diverticulum [11]. Symptoms persisted in 32% and 5% of patients, respectively, and the reoperation rate was 5% in each group.

These results support further study of additional decompression but do not show that aortopexy is equivalent to diverticulum resection. There was no group that was directly compared with resection, and plication and pexy were used in different combinations.

Size criteria should also not be confused. Bedin et al. compare the diverticulum with the descending aorta, whereas Perkins et al. use its ratio to the subclavian artery [5; 11]. The next step should be to compare specific procedures in terms of residual compression, dysphagia, reoperations and changes in vascular anatomy.

Chylothorax: a quality indicator requiring contextual interpretation

The most significant complication in the study by Bedin et al. was chylothorax, which occurred in 13 patients (22.4%). In double aortic arch, its incidence reached 43.8%

[5]. These data deserve separate analysis, even though the differences between groups were not statistically significant.

In the multicenter study by Schwartz et al., published in 2026, chylothorax occurred in 13.2% of vascular ring repairs, compared with 4.5% in the comparison group of cardiac surgical procedures [12]. Ajdaa et al., by contrast, reported a much lower rate of this complication in their surgical series [8].

Such wide variation rules out a simple explanation based on the anatomical type of the defect. Comparisons between centers should take into account diagnostic criteria, patient age, anatomical complexity, extent of dissection and postoperative follow-up. A possible link with lymphatic injury should be tested rather than assumed.

Likewise, finding no association between aortopexy and chylothorax does not prove that there is no effect, because a small number of events limits what the analysis can detect.

Limitations and unresolved issues

The retrospective single-center design, the unequal sizes of the anatomical groups and the lack of a control group limit any causal interpretation of the results [5]. Subgroups of four patients should be interpreted with particular caution. In addition, the criteria for aortopexy changed during the study period, which makes the surgical algorithm less consistent.

The primary endpoint, symptom resolution by discharge, is useful for assessing the immediate effect, but it depends on how long the patient stays in hospital. Children with complications stay longer and so have more time to recover. Clinical outcomes should therefore also be assessed at the same time points after surgery for all patients.

Several questions remain open: the prognostic significance of moderate asymptomatic stenosis, the benefits of early repair, indications for additional procedures and the prevention of chylothorax. A prospective study should assess not only respiratory symptoms but also swallowing, weight gain, the need for respiratory support, reinterventions and quality of life.

Minimally invasive techniques, including thoracoscopic and robot-assisted surgery, also need to be compared in this patient group. This should include their effect on recovery, complication rates and reintervention rates.

Conclusion

In young children, surgery for vascular rings relieves vascular compression and substantially reduces breathing and swallowing problems. However, good early results should not be mistaken for complete and lasting functional recovery. Persistent tracheobronchomalacia, residual compression and postoperative complications may shape the further course of the disease.

Treatment decisions should rest on a multidisciplinary approach that combines assessment of vascular anatomy, airway and esophageal function, symptom severity and the course of the disease. In an asymptomatic child, the presence of a vascular ring alone does not decide whether

or when surgery is needed. In the same way, the extent of the operation should be chosen for each patient, weighing the expected benefit of additional decompression against its risks.

The priorities for future research are to justify indications for preventive repair, find the optimal timing of intervention, compare surgical approaches and identify risk factors for chylothorax. Multicenter prospective studies with long-term follow-up and standardized assessment of breathing, swallowing, the need for reintervention and quality of life are needed to build an evidence-based treatment strategy.

References

- Movsesyan R.R., Soynov I.A. Pediatric cardiovascular surgery in Russia: from fundamental barriers to high-tech solutions. *Patologiya krovoobrashcheniya i kardiokhirurgiya = Circulation Pathology and Cardiac Surgery*. 2026;30(2):5-19. (In Russ.) <https://doi.org/10.21688/1681-3472-2026-2-5-19>
- Soynov I.A., Kim A.I., Movsesyan R.R., Teplov P.V., Miller A.Yu., Kulyabin Yu.Yu., Avramenko A.A., Gorbatiykh K.V., Gorbatiykh A.V., Nalimov K.A., Abramyan M.A., Boriskov M.V., Kovalev S.A., Svobodov A.A., Arkhipov A.N., Krivoshchekov E.V., Amansakhatova E.N., Tarasyuk E.S. Surgical Management of congenital heart diseases in the Russian Federation: national registry data for 2024. *Patologiya krovoobrashcheniya i kardiokhirurgiya = Circulation Pathology and Cardiac Surgery*. 2026;30(1):5-25. (In Russ.) <https://doi.org/10.21688/1681-3472-2026-1-5-25>
- Soynov I.A., Kim A.I., Movsesyan R.R., Teplov P.V., Miller A.Yu., Kulyabin Yu.Yu., Arkhipov A.N., Avramenko A.A., Gorbatiykh K.V., Gorbatiykh A.V., Nalimov K.A., Abramyan M.A., Boriskov M.V., Kovalev S.A., Svobodov A.A., Kauk A.V., Krivoshchekov E.V., Shikhranov A.A., Plotnikov M.V., Egunov O.A., Belov V.A., Gladyshev I.V., Kazantsev K.B., Kornoukhov O.Yu., Nokhrin A.V., Petrushenko D.Yu., Efanov E.S., Khalivopulo I.K., Ryabtsev D.V., Sobolev Yu.A., Medvedev V.N., Gavrilov R.Yu., Pavlov N.I., Amansakhatova E.N., Tarasyuk E.S. Outcomes of surgical repair of congenital heart disease in the Russian Federation in 2025. *Patologiya krovoobrashcheniya i kardiokhirurgiya = Circulation Pathology and Cardiac Surgery*. 2026;30(3):5-35. (In Russ.) <https://doi.org/10.21688/1681-3472-2026-3-5-35>
- Chiu P., Zendejas B., Baird C. Multidisciplinary approach to vascular rings and vascular-related aerodigestive compression: a clinical practice review. *Transl Pediatr*. 2023;12(6):1258-1277. PMID: 37427058; PMCID: PMC10326748. <https://doi.org/10.21037/tp-23-39>
- Bedin A.V., Shamrin Yu.N., Abramyan M.A., Korochkina E.S., Khasanova K.A., Kurako M.M., Gotskina A.Yu., Miroshnichenko V.P., Ovsiyannikov D.Yu. Early outcomes of surgical repair of vascular rings in infants and young children: a retrospective cohort study. *Patologiya krovoobrashcheniya i kardiokhirurgiya = Circulation Pathology and Cardiac Surgery*. 2026;30(3):36-48. (In Russ.) <https://doi.org/10.21688/1681-3472-2026-3-36-48>
- Korchagina D.O., Badurov R.B., Suvorov V.V., Starchik D.A. 3D printing for planning of surgery in a newborn with aortic arch pathology. *Russian Journal of Cardiology and Cardiovascular Surgery*. 2022;15(1):85-90. (In Russ.) <https://doi.org/10.17116/kardio20221501185>
- Voitov A.V., Manukian S.N., Vladimirov S.V., Borodin V.P., Kobelev E., Zhuravleva I.Yu., Arkhipov A.N., Gorbatiykh A.V., Rzayeva K.A., Nichay N.R., Bogachev-Prokophiev A.V., Soynov I.A. Implantation of a self-expanding transcatheter valve *in vitro* into a 3D heart model of a patient with right ventricular outflow tract dysfunction. *Siberian Journal of Clinical and Experimental Medicine*. 2024;39(2):104-111. (In Russ.) <https://doi.org/10.29001/2073-8552-2024-39-2-104-111>
- Ajdaa H., Carbonez K., Hubrechts J., Barrea C., de Beco G., Momeni M., Poncelet A.J. Pediatric vascular ring outcomes for surgically repaired vs. unoperated children: a single-center experience. *J Thorac Dis*. 2024;16(5):2790-2799. PMID: 38883675; PMCID: PMC11170419. <https://doi.org/10.21037/jtd-23-1526>
- Rato J., Zidere V., François K., Boon M., Depypere A., Simpson J.M., Speggorin S., Vigneswaran T.V. Post-operative Outcomes for Vascular Rings: A Systematic Review and Meta-analysis. *J Pediatr Surg*. 2023;58(9):1744-1753. PMID: 36967253. <https://doi.org/10.1016/j.jpedsurg.2023.02.058>
- Swarnkar P., Speggorin S., Austin B.C., Nyman A., Salih C., Zidere V., Simpson J.M., Vigneswaran T.V. Contemporary surgical outcome and symptomatic relief following vascular ring surgery in children: effect of prenatal diagnosis. *Eur J Cardiothorac Surg*. 2022;61(6):1260-1268. PMID: 35022705. <https://doi.org/10.1093/ejcts/ezab527>

11. Perkins A.A., Tomescu A.L., Knott-Craig C.J., Boston U., Spentzas T., Ramakrishnan K.V. Aortopexy With Plication of Kommerell Diverticulum Is an Effective Alternative to Diverticulum Resection and Reimplantation of the Aberrant Left Subclavian Artery for Surgical Management of Vascular Rings in Children. *World J Pediatr Congenit Heart Surg.* 2025;16(4):446-449. PMID: 40208045; PMCID: PMC12146880. <https://doi.org/10.1177/21501351251329912>
12. Schwartz S.P., Winder M.M., Bautista A.N., Fundora M.P., Calamaro J., Puente B.R.N., Plummer S.T., Greiten L.E., Bertrandt R.A., Sznycer-Taub N.R., Matiassek M.J., Norbistrath K.S., Milroy R., Lay A., Reeder R.W., Furlong-Dillard J.M., Prodhan P., Bailly D.K. Management Options for Chylothorax After Vascular Ring Repair: Retrospective, Multicenter Cohort in the United States, 2021-2023. *Pediatr Crit Care Med.* 2026;27(1):42-51. PMID: 41196121. <https://doi.org/10.1097/PCC.0000000000003855>