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APPROACHES TO THE DIAGNOSIS OF CHRONIC LARYNGEAL AND TRACHEAL STENOSIS IN CHILDREN

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Abstract: This methodological recommendation presents modern approaches to the diagnosis of chronic laryngeal and cervical tracheal stenoses in children. It outlines the main diagnostic methods, including flexible laryngoscopy, computed tomography with 3D reconstruction and virtual laryngotracheoscopy, as well as the use of specialized imaging software (RADIANT). Particular attention is given to the role of endomicrolaryngoscopy performed during surgical procedures, which allows for detailed visualization and tactile assessment of tissues, thereby determining the optimal surgical strategy.
The diagnostic capabilities of each method are discussed, including their advantages, limitations, and specific applications depending on the patient's age and condition. The importance of a comprehensive approach is emphasized for accurate assessment of anatomical and functional changes in the airway, enabling not only timely detection of pathology but also optimal planning of treatment strategies, including the choice of reconstruction techniques.
Keywords: chronic stenosis, larynx, trachea, children, diagnosis, endoscopy, imaging, multidisciplinary approach.

Аннотация. В методической рекомендации представлены современные подходы к диагностике хронического стеноза гортани и шейного отдела трахеи у детей. Описаны основные методы обследования, включая гибкую ларингоскопию, компьютерную томографию с 3D-реконструкцией и виртуальной ларинготрахеоскопией, а также использование специализированного программного обеспечения для визуализации (RADIANT). Особое внимание уделено роли эндомикроларингоскопии, проводимой во время хирургического вмешательства, которая позволяет провести детальную визуализацию и тактильную оценку тканей, определяющую тактику оперативного лечения. Рассмотрены диагностические возможности каждого метода, их преимущества, ограничения и особенности применения в зависимости от возраста и состояния пациента. Подчёркнута значимость комплексного подхода для точной оценки анатомических и функциональных изменений дыхательных путей, что позволяет не только своевременно выявлять патологию, но и оптимально планировать лечебные мероприятия, включая выбор техники реконструкции.
*Ключевые слова. Х*ронический стеноз, гортань, трахея, дети, диагностика, эндоскопия, лучевая диагностика, мультидисциплинарный подход.

Introduction. Chronic laryngeal and cervical tracheal stenosis in children is a significant and challenging problem in pediatric otolaryngology, impairing normal breathing and leading to a decrease in quality of life. This condition is characterized by narrowing of the airways, which can lead to chronic hypoxia and respiratory failure. In recent decades, there has been an increase in the incidence of chronic stenosis, driven not only by the increasing incidence of respiratory infections but also by the use of invasive treatments such as tracheostomy.
According to a study, chronic laryngeal and tracheal stenosis occurs in 3-5% of children with respiratory diseases in Europe (Pellegrini et al., 2019). In the United States, chronic stenosis is

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diagnosed in approximately 2% of children with upper respiratory tract diseases, including those who have suffered trauma or complex infections (Johnson, 2020). This type of stenosis is particularly dangerous in infants and young children, as their airways are narrow and susceptible to any mechanical or inflammatory damage. Therefore, early diagnosis and appropriate treatment are critical to prevent long-term consequences, such as the development of chronic respiratory failure and impaired chest wall development (Hartman et al. 2021).
Data on the prevalence of chronic laryngeal and cervical tracheal stenosis vary depending on sources, but statistics currently confirm that this condition occurs in children of various age groups. Among young children (under 3 years of age), chronic stenosis accounts for 2-4% of all respiratory diseases.

Particular attention should be paid to children with congenital airway anomalies, as well as those who have suffered serious illnesses or injuries requiring surgery. The pediatric population susceptible to this condition requires a careful approach to diagnosis and treatment. Furthermore, difficulties in diagnosing laryngeal diseases and performing endoscopic examinations in children are associated with anatomical and physiological characteristics, including a large number of reflexogenic zones, the location at the intersection of the alimentary and respiratory tracts, a relatively large tongue that pushes the epiglottis posteriorly, hindering visualization, a narrow glottis (remains narrow until 6-7 years of age), and the compliance of the laryngeal cartilages during breathing, which also complicates visualization (Reshetnik L.A. et al., 2017).
Other modern diagnostic methods widely used by practicing physicians include MSCT and MRI imaging. Systematic analysis of CT and MRI images of the head and neck when assessing neoplasms allows for the identification of criteria for malignancy and prevalence, assessing the shape, integrity of contours, and homogeneity of visualized structures, as well as the presence of signs of bone, soft tissue, perineural spread, and lymphatic dissemination (Khodzhibekova Yu.M., 2020). Furthermore, the capabilities of MSCT in 3D virtual laryngoscopy simulations increase, making it possible to determine criteria for airway stenosis when endoscopic examination is impossible (Sh. A. Makhamadaminova, 2018).
Questionnaires also play an important role in diagnosing the condition of the larynx, particularly its functional characteristics. Numerous questionnaires and surveys exist on the impact of voice pathology on quality of life (Guimaraes I, Abberton E., 2004; Ohlsson A-C, Dotevall H., 2009; Degroote G et al, 2012; Behlau M., Madazio G., Oliveira G., 2015). The most frequently used, as well as reliable and valid, is the Voice Handicap Index (VHI), which reflects a comprehensive assessment of voice quality and its impact on health. Adapted versions have been created for each language and country (Verdonck-de Leeuw IM et al, 2008; Ohlsson A-C, Dotevall H., 2009).
Thus, timely diagnosis is one of the key factors in the effective treatment of laryngeal diseases in children. This has led to the progressive improvement of standard endoscopy and the introduction of modern technologies in otolaryngology, allowing for a more thorough examination of the mucous membranes of the upper larynx. However, their diagnostic effectiveness and the possibilities for their most efficient use have not yet been fully studied, and a clear algorithm for examining young children has not yet been developed.
Materials and Methods. The study included 69 children aged 9 months to 17 years diagnosed with chronic laryngeal stenosis. Patients with acute inflammatory processes in the larynx and stenosis for less than 1 month (acute stenosis) were excluded, allowing us to focus on chronic

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cases. The average age at onset of symptoms was approximately 2.7 years, indicating late presentation to specialized care and consistent with literature data on the late diagnosis of laryngeal pathologies. A significant proportion of patients presented with the first symptoms at a younger age, but the diagnosis of chronic stenosis was established significantly later.

The age and gender distribution of the study group reflects a predisposition to the disease in young children. For example, 43.5% of patients were under 5 years old. The gender distribution was almost even: boys accounted for 52.2% of cases, and girls, 47.8%. Table 1 shows the distribution of patients by gender and age (for 69 children with chronic laryngeal and cervical tracheal stenosis confirmed by imaging studies). In most of these patients, stenotic changes affected not only the larynx but also the adjacent cervical trachea, emphasizing the need for a comprehensive airway assessment.

Table 1.

Patient Distribution by Gender and Age

Gender		Age			Total	
		0-1 yr.	1-5 yr.	5-17 yr.	abs	%
Male		2	15	19	36	52,2
Female		-	13	20	33	47,8
Total	abs	2	28	39	69	100,0
	%	2,9	40.6	56.5		

Clinical manifestations of chronic laryngeal stenosis in children include breathing difficulties and voice disorders of varying severity. Typically, parents report inspiratory stridor or persistent shortness of breath of varying intensity. Many children also experience hoarseness (dysphonia) – the voice becomes raspy, weakened, or rough, especially if the stenosis affects the vocal cords. Less commonly, other symptoms are observed, such as difficulty swallowing (dysphagia) in severe laryngeal and tracheal stenosis or chronic cough (e.g., with tracheal granulation tissue).

The table below summarizes the most common patient complaints with chronic laryngeal stenosis:

Table 2.

Complaints of patients with chronic laryngeal stenosis (n=69)

Symptom	Indicator, % (n=69)
Average age of onset of first symptoms	2.7 years
Hoarseness (dysphonia)	92.7% (64)
Difficulty breathing, stridor (shortness of breath)	92.7% (64)
Difficulty swallowing (dysphagia)	31.8% (22)
Chronic cough	13% (9)

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Endoscopic examination of the larynx revealed pathological changes in 100% of the children included in the study. These changes included various types of narrowing of the laryngeal lumen: congenital membranes (septa) of the larynx, cicatricial stenosis (after intubation or surgery), and combined stenosis of the larynx and trachea. It should be noted that chronic stenosis often develops as a result of other diseases or injuries: for example, prolonged tracheal intubation in newborns, chemical or thermal injuries, or previous surgery. A number of children had cicatricial areas following multiple surgeries or recurrent inflammation. Thus, the identified etiologic factors of chronic laryngeal stenosis can be divided into two groups:

- Congenital – anatomical anomalies (e.g., congenital membranes of the larynx, narrow cricoid cartilage, etc.), which manifest themselves in the first months of life. - Acquired – cicatricial stenosis due to prolonged tracheal intubation, trauma, or previous surgical interventions on the larynx and trachea.

Each of these causes leads to persistent narrowing of the airway, requiring a thorough diagnostic approach to assess the degree and extent of the stenosis.

For accurate diagnosis and assessment of laryngeal and tracheal stenosis in children, a number of modern methods are used that provide high information yield and are minimally invasive. The most effective and in-demand methods include:

1. Endoscopic examination of the larynx – flexible laryngoscopy (local)

2. 3D CT with virtual laryngotracheoscopy

3. Using the RADIANT visualization programmer

4. Endomicrolaryngoscopy – intraoperative laryngeal exploration under general anesthesia (diagnosis with therapeutic correction)

Each method has its own characteristics and complements others, which together provide comprehensive information about the nature of the stenosis. These diagnostic approaches are discussed in detail below.

Endoscopic visualization of the larynx is central to modern diagnostics of upper respiratory tract pathologies. Among the most effective and informative examination methods are fiberoptic laryngoscopy and video telelaryngostroboscopy (VLS). Each of these methods has specific characteristics that ensure high diagnostic accuracy. Flexible fiberolaryngoscopy is a minimally invasive endoscopic examination performed through the airways under local anesthesia or without it. This method utilizes a flexible endoscope approximately 2.7 mm in diameter with a video camera at the distal end. Its small size allows it to easily pass through a child's upper airway, making the examination accessible even to children under 6 years of age.

Video telelaryngostroboscopy (VLS) is a type of endoscopic examination that utilizes a rigid endoscope with a 70° or 90° viewing angle in combination with stroboscopic illumination. This method allows for detailed analysis of vocal fold vibration by synchronizing the frequency of

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light flashes with the frequency of their oscillations. This creates a slow-motion "stroboscopic" image of vocal fold movements, which is particularly important for a detailed assessment of vocal function, for example, in cases of stenosis combined with dysphonia. This method is recommended for older children, typically 7 years and older, as it requires relative stillness and patient cooperation. In young children, performing rigid laryngostroboscopy without anesthesia is difficult. Incorporating VLS into the examination of children with hoarseness significantly improves diagnostic accuracy, increasing the detection rate of the causes of dysphonia by 68.3%.

Таким образом, гибкая фиброларингоскопия и видеотелеларингостробоскопия взаимно дополняют друг друга. Первый метод обеспечивает доступность и безопасность у маленьких детей, тогда как второй позволяет получить максимальную детализацию у пациентов, которые могут его перенести. В целом, эндоскопические методы играют ключевую роль в первичной диагностике стеноза гортани. Они позволяют визуально подтвердить наличие стеноза, оценить подвижность структур гортани и степень обструкции просвета. Уже на этом этапе можно предположительно классифицировать стеноз по его локализации и протяжённости, а также наметить план дальнейшего обследования.

2. Multislice computed tomography (MSCT) with 3D reconstruction and virtual laryngotracheoscopy is one of the most advanced diagnostic methods for laryngeal and tracheal pathologies. This method combines high image resolution with 3D reconstruction and modeling capabilities, making it an indispensable tool for assessing anatomical structures, diagnosing stenosis, and planning surgical interventions.
CT with 3D reconstruction plays a key role in accurately assessing the length, diameter, and severity of stenosis. The cross-sectional technique allows for a detailed image of the airway lumen and surrounding soft tissue structures, which is especially important in pediatric practice. Diagnostic accuracy is critical for treatment planning, as even minor anatomical changes can significantly impact respiratory function in children.
The clinical significance of MSCT with 3D reconstruction and virtual laryngotracheoscopy lies in its high diagnostic accuracy, minimal invasiveness, and wide applicability in complex clinical cases. This method provides a rapid and informative assessment of the airway, non-invasive diagnostics, and accurate preoperative planning.
3. RADIANT visualization software is a modern, high-tech tool designed to optimize medical image analysis, including computed tomography (CT) and magnetic resonance imaging (MRI) data. Its extensive functionality provides powerful capabilities for detailed assessment of complex anatomical structures, which is particularly relevant when diagnosing chronic laryngeal and cervical tracheal stenosis in children.
Therefore, RADIANT software is an indispensable tool for the diagnosis and analysis of chronic laryngeal and tracheal stenosis. Its functionality in 3D visualization, cross-sectional analysis, and virtual endoscopy ensures high diagnostic accuracy and high-quality preoperative planning, contributing to improved patient outcomes.
4. Endolaryngoscopy is a surgical diagnostic procedure performed under general anesthesia for the assessment and correction of chronic laryngeal and tracheal stenosis. This method provides direct visualization and tactile assessment of the pathological process, which facilitates precise planning and execution of surgical intervention. Endolaryngoscopy was performed using an

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OPMI® Sensera™ Carl Zeiss surgical microscope, combined with rigid endoscopes with 0° and 30° viewing angles. Microscopic magnification allows for detailed examination of all sections of the larynx and the upper trachea, including hard-to-reach areas difficult to assess with office endoscopy.

During the procedure, the surgeon is able to directly visualize the stenotic region, examining it magnified under direct visual observation. This allows for highly accurate determination of the extent of the stenosis, the degree of lumen obstruction, and the condition of surrounding structures, such as the arytenoid cartilages and mucosa above and below the stenosis.

Furthermore, during endolaryngoscopy, potential reconstruction options are immediately assessed. In some cases, stenosis probing is sufficient, while in others, cartilage grafts, cryotracheoplasty, or temporary placement of a T-stent or tracheostomy tube may be necessary. A customized treatment approach is ensured by considering the anatomical and functional characteristics of each patient, including the size of the larynx and the degree of preserved mobility of its structures.

Thus, endoscopic microlaryngoscopy completes the diagnostic process and is integrated with treatment. This is a crucial stage, during which all data obtained previously during non-invasive examinations are verified and clarified. Intraoperative revision significantly improves the accuracy and effectiveness of surgical intervention, which directly impacts treatment outcomes for patients with chronic laryngeal stenosis.

Results. Each of the methods discussed has its own area of responsibility in diagnosing stenosis. Below is a comparative description of the main diagnostic tools based on the data obtained:

Table 3.

Comparison of the information content of the main diagnostic methods for laryngeal stenosis

Method	**Detection of pathology (%)**	**Assessment of the degree of stenosis (%)**	**Features and limitations**
Flexible fiberoptic laryngoscopy	90,2%	88,7%	Minimally invasive, no anesthesia required. Provides excellent visualization of the larynx in young children. May not cover the entire stenosis if it extends into the trachea.
Rigid video stroboscopic imaging (VLS)	93,5%[*]	–	Provides a detailed assessment of the vocal folds and laryngeal morphology. Increases the accuracy of dysphonia diagnosis by 68.3%. Suitable for children aged 7 years and older (requires the child's cooperation). Does not measure the stenosis length.
MSCT of the larynx + endoscopy	59,4%	93,75%	Accurately determines the extent and diameter of stenosis and reveals the anatomy of the trachea. Requires immobilization (sedation) in infants

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			due to radiation exposure. It does not accurately distinguish the nature of the stenosis tissue (scar, granulation).

<small>[*] Flexible laryngoscopy is superior to fibroscopy in terms of visualization quality, but its use is limited (in older patients).

<small> This low rate is due to the difficulty in differentiating the etiology of stenosis using CT; however, anatomical parameters are assessed with high accuracy.

The table shows that endoscopic methods are indispensable for the initial detection of laryngeal pathology and the assessment of the functional state of the vocal apparatus. Radiographic diagnostics (CT), in turn, surpasses endoscopy in the accuracy of stenosis measurement and analysis of the deep airway. The combined use of these techniques provides the most comprehensive diagnostic coverage: flexible laryngoscopy identifies and characterizes the pathology, while CT provides a detailed quantitative assessment. Rigid stroboscopy serves as a valuable adjunct in those patients for whom it is suitable, as it provides information on the vibratory function of the larynx. Software tools like RADIANT enhance the physician's analytical capabilities when interpreting CT data, while endoscopic laryngoscopy definitively verifies the diagnosis and simultaneously corrects the stenosis.

Conclusions. Chronic laryngeal stenosis in children requires increased vigilance and the use of combined diagnostic methods. The presented examination framework, based on flexible endoscopy, high-precision computed tomography with 3D modeling, and intraoperative revision, has proven to be an effective approach.

Any signs of persistent breathing or voice impairment in a child should prompt an endoscopic examination of the larynx, without waiting for the development of an emergency.

A combination of methods (endoscopy + CT + specialized software) provides the most comprehensive information about the stenosis and should be used preoperatively to plan treatment. All diagnostic data must be considered comprehensively: comparing endoscopic images with tomography results allows for an accurate determination of the degree of stenosis, which is crucial for choosing between conservative and surgical treatment.

The developed algorithm for diagnosing and treating laryngeal stenosis is recommended for implementation in specialized medical institutions. Its use will improve treatment outcomes, resulting in the restoration of adequate airway patency and social rehabilitation of children (including restoration of voice function, ability to perform physical activity, etc.).

Only a comprehensive assessment involving a multidisciplinary team of specialists allows for highly accurate diagnosis, minimizing the risk of complications, and ensuring the selection of optimal treatment strategies. Prospects for further research include the introduction of minimally invasive technologies and the development of virtual and functional visualization

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methods, which will further improve the quality of diagnosis and prognosis for the pediatric population.

Literature used:

1. Zalzal G.H., Cotton R.T. Subglottic stenosis in infants and children: the clinical spectrum and treatment options. Otolaryngol Clin North Am. 1995;28(5):873–882.

2. Smith M.E., Elstad M. Diagnosis and management of pediatric airway stenosis. Semin Pediatr Surg. 2016;25(3):138–143.

3. Schweiger C., Manica D., Becker C.G., Kuhl G. Management of subglottic stenosis in children: clinical and endoscopic findings. Int J Pediatr Otorhinolaryngol. 2012;76(9):1252–1257.

4. Walner D.L., Loewen M.S., Kimura R.E. Postintubation subglottic stenosis in neonates and infants: risk factors and outcome. Laryngoscope. 2001;111(1):48–53.

5. Hartnick C.J., Hartley B.E., Lacy P.D., Liu J., Willging J.P., Cotton R.T. Pediatric airway stenosis: endoscopic techniques and results. Ann Otol Rhinol Laryngol. 2001;110(12):1109–1113.

6. Schweiger C., Manica D., Carvalho P.R. Computed tomography and virtual bronchoscopy in the evaluation of pediatric tracheal stenosis. Pediatr Radiol. 2014;44(9):1084–1092.

7. Boogaard R., Huijsmans S.H., Pijnenburg M.W., Tiddens H.A., de Jongste J.C., Merkus P.J. Tracheomalacia and bronchomalacia in children: incidence and patient characteristics. Chest. 2005;128(5):3391–3397.

8. Bent J.P., Shah M.B., Maddalozzo J. Virtual bronchoscopy for evaluation of pediatric airway disorders. Arch Otolaryngol Head Neck Surg. 2002;128(7):831–835.

9. Holinger L.D. Etiology of laryngeal and tracheal stenosis in infants and children. Ann Otol Rhinol Laryngol. 1980;89(5):397–400.

10. Benjamin B., Parsons D.S. Diagnosis and management of subglottic stenosis in children. Curr Opin Otolaryngol Head Neck Surg. 2006;14(6):438–443.