3.1.3. Otorhinolaryngology / 3.1.3. Оториноларингология

Current view on diagnostic methods and risk factors of post-intubation laryngeal stenosis in pediatric patients

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Современный взгляд на методы диагностики и факторы риска постинтубационного стеноза гортани у детей

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儿童患者插管后喉狭窄的诊断方法与危险因素研究现状

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Laryngeal injury is a very common complication after intubation, especially in children. It carries a great economic burden for parents and the medical system and greatly disrupts the child's physical and social development. Treatment of chronic post-intubation complications is time-consuming and resource-intensive and may end up unsuccessful even after many years. To prevent the development of laryngeal stenosis in children after intubation, careful evaluation of the risk factors leading to soft tissue scarring is necessary. Our goal was to analyze the literature on the incidence of post-intubation laryngeal injuries in children and the underlying risk factors. We reviewed the literature on post-intubation laryngeal complications available in the following databases: Clinicalkey, PubMed, PubMed Central, UptoDate, and Embase. According to the collected data, we categorized all factors into patient-related and procedure-related. However, all risk factors have a low level of evidence, which requires additional studies in the future.

Keywords: laryngotracheal stenosis, pediatric airway, subglottic stenosis, risk factors

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Травма гортани является очень распространенным осложнением после интубации, особенно у детей. Она несет большую экономическую нагрузку для родителей и медицинской системы, значительно нарушает физическое и социальное развитие ребенка. Лечение хронических постинтубационных осложнений требует много времени и ресурсов и даже спустя много лет может оказаться безуспешным. Чтобы предотвратить развитие стеноза гортани у детей после интубации, необходимо тщательно изучить факторы риска, приводящие к рубцеванию мягких тканей. Цель – проанализировать литературу по теме частоты постинтубационных травм гортани у детей и их основных факторов риска. Мы изучили литературу по теме осложнений гортани после интубации, представленную в следующих базах данных: Clinicalkey, PubMed, PubMed central, UptoDate и Embase. Согласно собранным данным, мы разделили все факторы, на связанные с пациентом и связанные с процедурой. Однако все факторы риска имеют низкий уровень доказательности, что требует дополнительных исследований в будущем.
Ключевые слова: стеноз гортани и трахеи, дыхательные пути у детей, подсвязочный стеноз, факторы риска

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喉部损伤是插管后十分常见的并发症，在儿童患者中尤为突出。这种情况不仅给患儿家庭和医疗系统带来沉重的经济负担，还会严重影响儿童的生理发育和社会功能发展。慢性插管后并发症的治疗往往耗时耗力，即使经过多年治疗仍可能以失败告终。为预防儿童插管后喉狭窄的发生，必须对导致软组织瘢痕形成的危险因素进行仔细评估。

本研究旨在通过文献分析探讨儿童插管后喉损伤的发生率及其相关危险因素。我们检索了Clinicalkey、PubMed、PubMed Central、UptoDate和Embase等数据库中关于插管后喉部并发症的文献。根据收集的数据，我们将所有危险因素分为患者相关因素和操作相关因素两大类。然而，目前所有危险因素的证据等级都较低，未来仍需开展更多研究加以验证。
关键词: 喉气管狭窄、儿童气道、声门下狭窄、危险因素

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Introduction

Post-intubation laryngeal stenosis (PILS) remains a significant complication in pediatric patients, particularly in those requiring prolonged or repeated intubation [1]. This condition, characterized by narrowing of the laryngeal airway due to scarring, poses a critical challenge in clinical practice due to its impact on airway patency and long-term morbidity [2]. Early diagnosis and accurate risk stratification are essential to minimize complications and guide timely interventions.

The etiology of PILS is multifactorial, encompassing patient-related [3], procedural [4], and environmental factors [5]. Advances

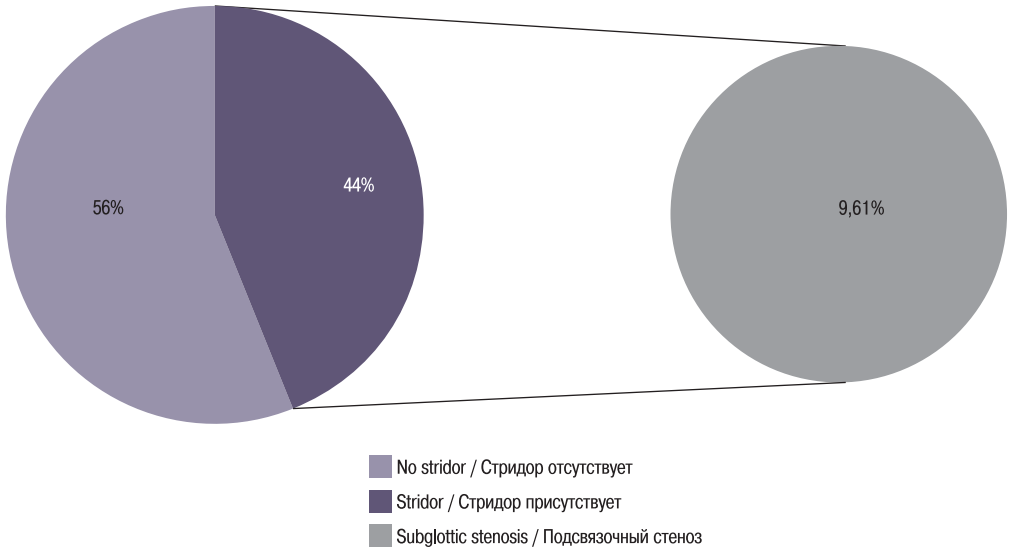

Fig. 1. The incidence of post-extubation stridor among children by L.L. Veder, et al. [1]
Рис. 1. Частота встречаемости стридора после экстубации у детей по данным L.L. Veder, et al. [1]

in diagnostic modalities, including imaging techniques [6] and endoscopic evaluations [7], have improved the ability to detect laryngeal stenosis [8]. However, variability in clinical presentation and diagnostic accuracy often complicates early identification [9]. Additionally, understanding the risk factors – such as age [10], intubation duration [11], and underlying comorbidities [12] – plays a pivotal role in prevention and management strategies.

This review aims to provide a comprehensive analysis of the current diagnostic methods and risk factors associated with PILS in pediatric patients. By synthesizing recent evidence, the review highlights gaps in knowledge and offers insights into optimizing clinical approaches to reduce the incidence and severity of this condition.

Incidence of Laryngeal Injury

The reported incidence of post-extubation laryngeal injuries varies significantly across studies. Post-extubation stridor was observed in 1.0 to 30.3% (Fig. 1), post-extubation upper airway obstruction in 1.2 to 39.6%, laryngeal injury found at laryngoscopy in 34.9 to 97.0%, diagnosed laryngotracheal stenosis (LTS) in 0 to 11.1% [13].

After a brief period of intubation (1.0 and 4.5%), there was a decreased incidence of post-extubation stridor [2] (Fig. 2). Children with trisomy had a high rate of complications of PILS of 30% [14], and then an important factor was the performance of cardiac surgery for congenital defects [15], as well as the duration of stay under the tube [16].

Edema and erythema were reported in 34.9 to 97% with recovery rates of 3.0 to 65,1% [17].

The forms of damage to the larynx and trachea after insertion of the tube were studied (Fig. 3). Up to 30% of patients had some form of damage, which was expressed in stridor in 12% of patients, while recovery occurred in almost all (92%) [18].

These variations highlight the importance of considering both the patient's medical background and the specifics of their intubation procedure.

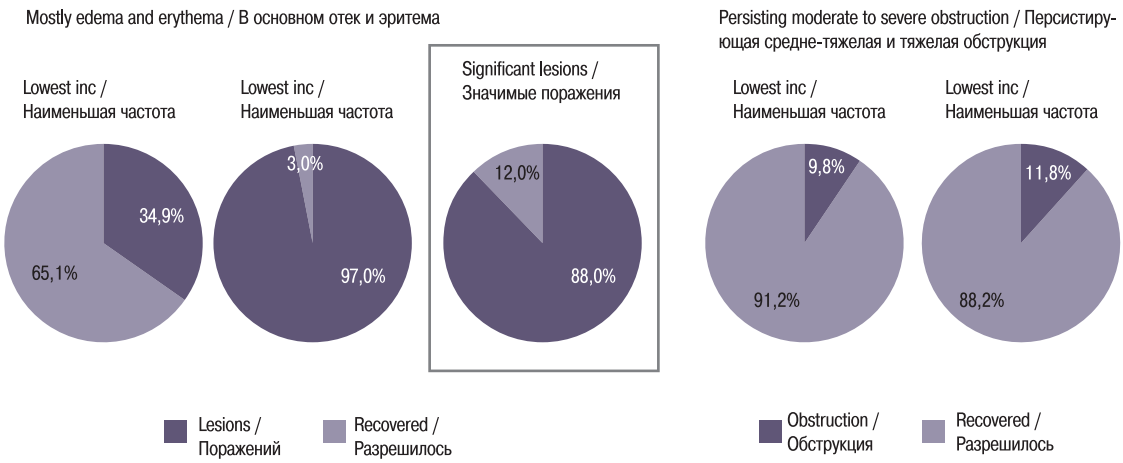

Fig. 2. Endoscopic confirmed lesions within two days after extubation according to de M. Wit, et al. [2]
Рис. 2. Эндоскопически подтвержденные поражения через 2 суток после экстубации по данным de M. Wit, et al. [2]

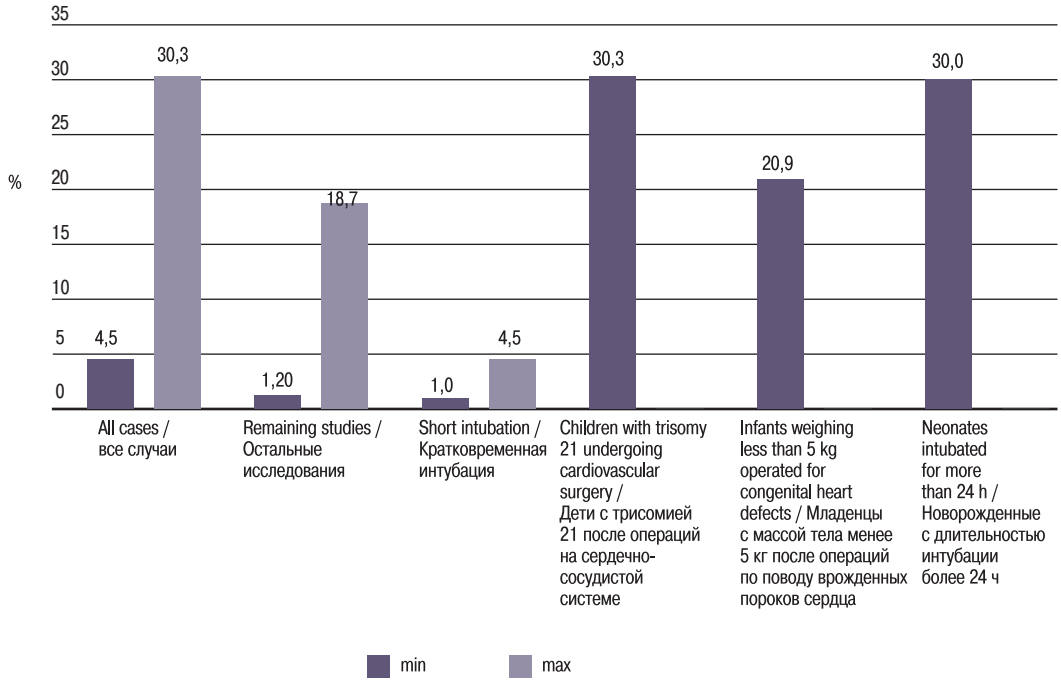

Fig. 3. Post-extubation stridor incidence among infants according to de A.L. Jong, et al [3]
Рис. 3. Частота встречаемости стридора после экстубации среди младенцев по данным de A.L. Jong, et al [3]

Patient-Related Risk Factors

The review identifies several patient-related factors that may increase the risk of post-intubation laryngeal injuries:

1. Requirement for additional sedation doses: Severe laryngeal injuries were reported in 44.2–66.7% of cases; however, the authors highlighted a very low level of evidence for this association [19].
2. Gastroesophageal reflux (GER): GER is a common risk factor for post-extubation upper airway obstruction and LTS [20].
3. Younger age: Neonates and younger children are particularly vulnerable to such injuries. However, there is no statistically significant relationship between the incidence of stenosis and age [21].
4. Low body weight: One study reported lower body weight as a significant risk factor, but seven other studies found no correlation [22].
5. Gender. Although some studies have shown a link between the occurrence of stenosis and gender, this link has not been statistically proven [23].
6. Comorbidities: Conditions such as trisomy 21 and GER significantly increase the likelihood of laryngeal injuries [24].
7. Infections: Infections may complicate post-extubation recovery according to some studies, but the overall level of evidence for this association was rated as very low [25].

Procedure-Related Risk Factors

We highlight eight procedural factors associated with an increased risk of laryngeal injury:

1. Prolonged intubation: the risk of laryngeal damage increases with the duration of intubation [26]. However, conflicting results and a critical risk of bias result in a very low level of evidence. This also applies to multiple intubation attempts.
2. Traumatic intubation: difficult or forceful intubation is linked to a higher risk of injury in some studies, but overall evidence is rated as very low [27].
3. Use of oversized tubes: tubes that are larger than necessary for the patient's age or size can cause airway trauma. Despite this, conflicting findings and a critical risk of bias lead to a very low level of evidence [28].
4. Absence of an air leak: this has been suggested as a risk factor for laryngeal injury, but, as with other factors, conflicting results and a critical risk of bias contribute to a very low level of evidence [29].
5. Others: Unrelated factors as gestational age and intubation ability, cuffed tube usage, and steroid treatment cannot show an association with laryngeal injury [30-33].

Classification

Over the past 10 years, there has been an active discussion about the grading of the stenosis degree in children. In response, various classification systems have developed in the literature to encapsulate the intricate anatomy, clinical variability, and treatment alternatives related to these conditions [34]. This chapter delineates the principal classification systems employed to inform diagnosis and management.

Myer-Cotton. This type of classification is most adapted to modern clinical manifestations of stenosis and is convenient from the point of view of assessment using endoscopy. It considers subglottic, laryngeal and tracheal stenosis in adults and children [35]. When it comes to the classification, there are four different categories that are decided by the proportion of lumen obstruction: grade I: there is a decline of 0 to 50 percent; Gradation II: a decrease of 51–70%;

Grade III: a decline of 71–99% total; Complete occlusion with no discernible lumen is the fourth grade of obstruction;

McCaffrey. This system was developed by McCaffrey to identify the location of stenosis [36] in adults and children. Using both univariate and multivariate analysis, the classification was formed. The findings of these studies revealed that the anatomical site is the most reliable predictor of the amount of time required for decannulation. The classification consists of the following four groups:

- Stenosis that is either restricted to the subglottis or the trachea, with a craniocaudal extension that is less than one centimeter is the first stage.
- Stenosis is expressed in the subglottic ares, with a spread of more than 1 centimeter.
- Stenosis that affects both the subglottis and the trachea is part of the third stage.
- Grade 4 stenosis extends along the larynx, with scarring and paralysis of at least one vocal cord.

Lano-Netterville. This classification is based on the number of involved areas of the respiratory tract, which consists of three types of stenosis:

Stage I: Involvement of one subsite; Stage II: Involvement of two subsites; Stage III: Involvement of both the glottis and trachea.

The authors supported the implementation of this system based on its significant correlation with surgical outcomes and disease stage. Surgical success rates in the retrospective analysis were 94% for Stage I, 78% for Stage II, and 20% for Stage III.

Table The laryngeal stenosis classification system
Таблица Классификация стеноза гортани

Stenosis type *Тип стеноза*	Differences *Различия*	Developing *Развивающийся*	Characterized by acute airway narrowing (e.g., edema, ulcerations, granulation tissue) which requires treatment to prevent cicatricial stenosis *Характеризуется острым сужением дыхательных путей (например, отеком, изъязвлениями, грануляционной тканью), которое требует лечения для предотвращения рубцового стеноза*
		Developed *Развившийся*	Represents established narrowing, typically treated surgically *Представляет собой сформировавшееся сужение, обычно лечится хирургическим путем*
	Endoscopic tools Эндоскопические инструменты	The Myer–Cotton Airway Grading System *Шкала оценки стеноза Myer–Cotton*	employed to quantify the severity of stenosis (Grades I–IV) *Используется для количественной оценки тяжести стеноза (степени I-IV)*
Involved subsites *Задействованные области*	Direct laryngoscopy and TNFL *Прямая ларингоскопия и ТНФЛ*	Identifies the location (supraglottic, glottic, subglottic, tracheal) and extent of involvement *Определяет локализацию (надсвязочное, в области голосовых свяхок, подсвязочное, трахеальное) и степень поражения*	
		If multiple sites are affected, it is recorded accordingly *Если поражено несколько областей, это фиксируется соответствующим образом*	
Extension *Протяженность*	Measurement using telescopes *Эндоскопическое измерение*	Telescopic measurements assess the length of stenosis from the vocal folds to the tracheostoma, using instruments like the rod-lens telescope *Эндоскопически оценивают протяженность стеноза от голосовых складок до трахеостомы, используя такие инструменты, как телескоп с линзой*	This step ensures detailed mapping of the cranio-caudal extent, essential for surgical planning *Этот этап обеспечивает детальное картирование кранио-каудальной протяженности, что необходимо для планирования хирургического вмешательства*
Laryngeal motility *Подвижность голосовых связок*	Awake TNFL *ТНФЛ в состоянии бодрствования*	Provides a primary assessment of vocal fold (VF) mobility *Обеспечивает первичную оценку подвижности голосовых складок (ГС)*	It checks for normal VF movement, restricted abduction (common with PGS), or VF immobility (due to paralysis or joint fixation) *Оценивают нормальное движение ГС, ограничение абдукции (характерно для СЗС) или неподвижность ГС (из-за паралича или фиксации сустава)*
	Asleep TNFL *ТНФЛ в бессознательном состоянии*	Used if awake assessment fails or is inconclusive, especially in children or uncooperative patient *Используется, если оценка в бодрствующем состоянии не удается или не дает результатов, особенно у детей или пациентов, не доступных коммуникации*	
	Microlaryngoscopy with retraction instruments *Микроларингоскопия с использованием ретракционных инструментов*		Differentiates between neurogenic paralysis and PGS by observing arytenoid movements and interarytenoid adhesion *Помогает дифференцировать нейрогенный паралич и СЗС, наблюдая за движениями черпаловидного хряща и межчерпаловидными адгезиями*
Airway lumen *Просвет дыхательных путей*	The Myer–Cotton grading system *Шкала оценки Myer–Cotton*		(Grade I–IV) evaluates the degree of airway obstruction *(I-IV степень) оценивает степень обструкции дыхательных путей*

Note. TNFL – Transnasal Fiberoptic Laryngoscopy, PGS – posterior glottic stenosis.
Примечание. ТНФЛ – трансназальная фиброоптическая ларингоскопия, СЗС – стеноз задней стенки гортани

Cohen. Indicated only for congenital interligamentous membrane, which may also be associated with variable manifestations of stridor [38]. This classification comprises four categories determined by the degree of glottic lumen involvement.

Type 1: Involves 35% or less of the glottic lumen; Type 2: Involves 35–50% of the glottic lumen; Type 3: Involves 51–75% of the glottic lumen; Type 4: Involves 76% or more of the glottic lumen.

This system enables clinicians to assess the severity of obstruction and customize management strategies accordingly.

Bogdasaryan, et al. The classification proposed by the group of authors is aimed at the category of patients with posterior PILS of the larynx [39]. This system is aimed at assessing the respiratory function, the diameter of the larynx, the localization of stenosis and its extent. According to the FLECS staging system, the assessment is carried out in a comprehensive manner [40].

European Laryngological Society Classification. ELS proposed a system for preoperative endoscopic airway assessment, which consists of 5 pathways [8]. Below are the main classification criteria for determining the severity of laryngeal stenosis (table.).

The ELS classifications have been applied to large retrospective cohorts from the centers involved in its development [8], confirming its accuracy in predicting both peri-operative outcomes, such as complication rates and the need for further treatments, as well as long-term outcomes, including decannulation rates, in both pediatric and adult populations affected by LTS and treated with tracheal or crico-tracheal resection and anastomosis. The value of this factor in predicting outcomes for patients undergoing endoscopic treatments has not yet been evaluated.

There are five standardized sequential steps for diagnosing postintubation laryngeal stenosis:

1. Awake indirect laryngoscopy (TNFL) this method is employed to assess vocal fold (VF) mobility in conscious patients and to identify PGS, neurogenic VF paralysis, or cricoarytenoid joint fixation;
2. Asleep TNFL; Facilitates a dynamic airway assessment during anesthesia for both pediatric and adult populations;
3. Direct transoral laryngotracheoscopy utilizing a bare zero-degree rod-lens telescope; facilitates visualization of the stenotic segment in relation to the vocal folds and tracheostoma, and allows for measurement of the length and grade of the stenosis;
4. Suspension microlaryngoscopy; utilized to distinguish between vocal fold paralysis and PGS;
5. Bronchoesophagoscopy: Critical for evaluating the lower airways and esophagus in patients with LTS.

Diagnostic tools

Functional assessment refers to the systematic evaluation of an individual's performance in various tasks and activities, often to determine their capabilities and needs in specific contexts.

Прежде всего, важно оценить голосовую и дыхательную функцию, работу легочного аппарата. Для оценивания голосового аппарата используются стандартизированные шкалы, которую далее должны документироваться [41].

Radiological evaluation. The use of radiological evaluation for stenosis in pediatric patients is a subject of ongoing debate. CT scans are essential for evaluating the craniocaudal extent and severity of airway obstruction [42]. Additionally, they provide 3D reconstructions of the airways, which is especially beneficial when awake TNFL fails to deliver adequate visualization [43]. In cases of Cotton–Meyer grade III or IV stenosis, radiological imaging is essential prior to any sedation or general anesthesia, except in emergencies requiring immediate tracheotomy [44].

For the assessment of neck masses or mediastinal vascular anomalies, standard CT or MRI scans may be necessary. Sedation must always be conducted under the supervision of an anesthetist. MRI is favored due to its superior resolution, rendering it ideal for assessing airway compression resulting from mediastinal abnormalities.

Health Status. A comprehensive evaluation of comorbid diseases is essential in the assessment of airway stenosis. This includes pulmonary and cardiac assessments to confirm adequate respiratory and circulatory function, as well as a comprehensive neurological evaluation to identify any potential impairments that may affect airway management. In individuals with a tracheostomy history, the severity of stenosis can be evaluated by temporarily occluding the tracheostomy cannula. This provides immediate assessment of the patient's pulmonary function and the degree of airflow resistance in the stenotic region, particularly in cases of diminished airflow or elevated pressure [45]. To form a diagnosis in the ELS system, the degree of stenosis according to Mayer–Cotton, Lano–Netterwild observation, and additional diseases are taken into account. The Myer–Cotton score ranks the degree of airway stenosis into four grades: Grade I implies mild obstruction; Grade IV represents complete occlusion.

The updated Lano–Netterville classification then is used, which includes a fourth anatomical subsite – the supraglottis. Engagement at a site is represented as follows: involvement of one location. Involvement increases gradually; indicates that all four subsites – supraglottis, glottis, subglottis, and trachea – are affected. A "+" symbol is applied to the final score in cases when the patient shows notable comorbidities or congenital abnormalities, therefore indicating the increased clinical load that could influence treatment outcomes. This rating system forecasts surgical outcomes and helps in treatment planning.

The ELS classification offers a whole framework for the management of LTS, therefore aiding the development of diagnosis and therapy planning [46]. The three-dimensional framework of the scoring system evaluates the cranio-caudal degree of stenosis as well as its minimum axial plane diameter. The classification emphasizes the need of comorbidities, which are crucial for decision-making and so guarantee that treatment planning takes the patient's whole state into account. This all-encompassing strategy improves treatment result prediction and quality of treatment.

Preoperatively endoscopic review. Many necessary tests targeted at completely examining the airway make up the endoscopic diagnostic assessment for LTS. Among the methods include bronchoesophagoscopy, direct transoral laryngoscopy, suspension microlaryngoscopy, and TNFL [47]. CT, MRI is an optional component in the preoperative preparation of patients with stenosis. General examination, respiratory function assessment and other tests should be performed [48].

TNFL. An integral component of in-office airway examination is TNFL. It is necessary to check the patency starting from the nasal cavity and ending with the larynx [49].

Diagnosing obstructive supraglottic lesions – including laryngomalacia, lymphovascular abnormalities, and cysts – also depends on flexible nasoendoscopy. It assesses vocal fold movement and points up signs of impaired swallowing, including secretions accumulating in the hypopharyngeal channel. To differentiate between neurogenic bilateral paresis/paralysis of the vocal cords and stenosis in the posterior commissure of the glottis, it is necessary

to perform an endoscopic examination under general anesthesia. Still, TNFL has limitations since this technique still slightly hides the trachea and subglottic area [50].

Not every patient depends on direct laryngoscopy. If laryngomalacia is suspected, further examination with a laryngoscope should not be performed. However, if the patient has stridor and other clinical symptoms of stenosis, then invasive diagnostic methods should be performed.

TNF in Sleep. The presence of developmental delay in a child combined with problems of feeding, sleep and breathing requires transnasal fibrolaryngoscopy under general anesthesia, especially relevant for active and small children who find it difficult to follow instructions [51]. Either intravenous propofol or sevoflurane is used for anesthesia; atropine is given intravenously prior to the operation to prevent bradycardia [52].

This method also allows to identify other pathologies not associated with the larynx (hypertrophy of adenoids, atresia of the choanae, tumors, etc.) Also, problems with the muscular system, hypertrophy of the tonsils, prolapse of the epiglottis can also be the cause of stridor, so it is necessary to exclude them first. Particularly during the preoperative assessment of subglottic stenosis (SGS), both awake and asleep TNFL are vital for the comprehensive investigation of a damaged airway [53].

Direct laryngoscopy. This diagnostic method is complex, so sedation is required before it is performed. A complete examination of the larynx is achieved using a 4 mm rigid Storz endoscope [54]. Even minor damage to the mucous membrane can cause obstruction, so great care is required. There are stands with a smaller diameter (2.7 and 1 mm), which is most effective for small children.

Typically evaluated using the Myer–Cotton grading system, which runs telescopes or bougies of varying diameters across the stenotic segment to determine the degree of narrowing, the severity of SGS, interference with suspension makes a tracheostomy resulting from procedural trauma or airway compromise unsuitable for a diagnostic endoscopy [55].

Micro-laryngoscopy. Benjamin- Lindholm laryngoscope is perfect for clear pharynx, larynx, and subglottis view during an airway examination. Several experts' instruments define the process: 0° and 70° telescopes, the Lindholm vocal cord retractor, angulated probes, and tapered bougies.

Although the degree of airway narrowing is measured with bougies, telescopes help to ascertain the craniocaudal extension of the stenosis. The telescope advances to the vocal folds, noting any pathological changes in the larynx along the way. The underlying structures are examined through the tracheotomy. Especially in preparation for tracheal resections and anastomoses, these accurate measurements are quite important [56]. More complex and severe types of laryngeal stenosis should be examined by creating a 3D model, especially in patients with a history of intubation.

PGS can be further separated and categorized utilizing Bogdasarian's method by means of an angulated probe, therefore ensuring correct diagnosis and appropriate treatment planning.

Bronchoesophagoscopy. Bronchoesophagoscopy is indicated for almost all patients with stenosis, especially chronic cerebrospinal fluid carriers [57]. In SGS, a soft bronchoscope should be used, also for the tracheotomy opening, which allows for a better assessment of the condition of the lower respiratory tract, esophagus. A rigid bronchoscope is used in cases of laryngeal resection, for an adequate assessment of the condition of the cartilages, the distance between the carina and the tracheostomy [58].The bronchoscopy should investigate acquired or congenital anomalies including tracheoesophageal fistula, malacia, extrinsic compression, or injuries resulting from the suction or cannula. To keep interference from bleeding throughout the examination, bronchoalveolar lavage and biopsiesshought to follow. The identification of infections that may compromise surgical outcomes requires a bacteriological examination of secretions, thus averting challenges which includes graft infections or anastomotic dehiscence.

Alongside bronchoscopy, esophagoscopy – using rigid or flexible scopes – helps assess GER diesease and eosinophilic esophagitis [59]. While 24-hour pH monitoring or impedancemetry is more accurate for diagnosing GOR, endoscopy can reveal erosive esophagitis. If the angle of His is absent or the cardia opens directly into the gastric pouch, chronic reflux may result. Biopsies of thickened or ringed esophageal mucosa confirm eosinophilic esophagitis.

Decision Making. To achieve maximum surgical efficiency in children with PILS of the larynx and trachea, a comprehensive approach to the initial assessment is necessary. The proposed classifications are necessary for an adequate assessment of the stenosis degree. The previously described diagnostic methods can be used both separately and in combination, leaving the final word to the medical council. An important task of surgical treatment of stenosis is the removal of the tracheostomy tube, which significantly improves the surgery outcome, the quality of life of young patients. Successful treatment ensures that laryngeal function is preserved, balancing the need to reopen the airway with maintaining the patient's ability to protect against aspiration and communicate effectively.

Discussion

Our review was devoted to the topical issue of laryngeal and tracheal stenosis that arose after intubation. We made a thorough literature review on this topic, analyzed the factors influencing the development of tissue scarring, defined classification systems and modern diagnostic methods.

The incidence of post-intubation laryngeal stenosis is approximately 30% [1, 6], although there is a wide variation in subtypes of stenosis. Younger age, gastrointestinal reflux, and comorbidities such trisomy 21 have been connected to a higher incidence of these injuries [3, 8] as well as other patient-related elements. Furthermore adding to the risk are procedure-related factors including extended or traumatic intubation and the use of large tubes, but the data supporting these links is sometimes contradicting [2, 4, 5]. These differences highlight the need of tailored patient evaluations and careful intubation methods to reduce possible consequences [1, 2]. Defining these risk factors and creating standardized processes for preventing post-extubation laryngeal injury [3, 8] depend on additional research.

Over recent decades, the diverse presentations of LTS have driven the development of multiple classification systems to standardize definitions and guide management [12–14]. The Myer-Cotton classification, for instance, categorizes stenosis severity based on the percentage of luminal obstruction and is widely used for mature subglottic lesions [12]. McCaffrey's system extends this approach by considering the anatomical involvement of the glottis, subglottis, and trachea, which has proven useful in predicting decannulation times [13]. The Lano–Netterville staging simplifies assessment by focusing on the number of affected subsites, with surgical outcomes correlating with each stage [14]. Moreover, recent consensus by the European Laryngological Society has incorporated detailed endoscopic evaluations and objective measurements to further refine diagnostic precision and treatment planning [8].

Combining extensive endoscopic assessments, including TNFL, direct transoral laryngoscopy, and bronchoesophagoscopy with thorough functional assessments including voice evaluation using the GRBAS scale, spirometry, and radiological imaging like CT and MRI, the diagnostic workup for LTS is this all-encompassing technique guarantees correct stenosis mapping, comorbidity evaluation, and finally directs customized therapy based on best results.

Limitations

For generalization of findings related to the available literature is limited, as the search was related only to PILS. In addition, there is heterogeneity in the data, which makes it difficult to combine the results

Conclusion

Laryngeal stenosis in children is a complex condition that significantly affects both short- and long-term health, making accurate diagnosis and effective management crucial. Our review highlights the importance of thorough diagnostic approaches, from endoscopic exams to radiologic imaging, alongside understanding patient- and procedure-related risk factors. By recognizing these risk factors – such as prolonged intubation, younger age, and conditions like GER – clinicians can better anticipate and work to prevent complications.

Standardized tools like the European Laryngological Society's classification system and the Myer-Cotton grading help bring consistency to diagnoses and treatment planning, but every patient's situation is unique. Because of this, we emphasize the need for flexible, personalized approaches that cater to each patient's specific risks and needs.

Looking ahead, more research is needed to solidify the evidence around risk factors and to refine diagnostic methods, ideally making them less invasive for children. With a growing focus on both prevention and individualized care, we hope to support better outcomes and quality of life for young patients facing laryngeal stenosis.

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