www.brn.cat

PERMANYER

BRN Rev. 2025;11(1):33-46

BRN Reviews

REVIEW ARTICLE

Chronic pulmonary aspiration in children

Anna Campanario-Cañizo[1], José A. Gil-Sánchez[1,2], José A. Peña-Zarza[1,2], and Joan Figuerola-Mulet[1,2]*

[1]Department of Pediatrics, Hospital Universitario Son Espases; [2]Health Research Institute of the Balearic Islands (IdISBa). Palma de Mallorca, Mallorca, Spain

ABSTRACT

Chronic pulmonary aspiration is a common issue in the pediatric population, particularly in patients with neurological conditions, anatomical malformations, and infants with a history of prematurity. Its clinical manifestations are highly varied, with chronic cough, wheezing, recurrent bronchitis, and pneumonia being the most prominent. In many cases, aspiration may be silent, going unnoticed until it results in severe pulmonary damage. Aspiration due to swallowing dysfunction may occur either basally with the aspiration of saliva or during feeding. To diagnose this condition, we have diagnostic tools such as videofluoroscopy and fiber-optic swallowing endoscopy. Respiratory manifestations of gastro-esophageal reflux may occur in the absence of digestive symptoms. There is no gold standard for its diagnosis, making it essential to conduct a thorough assessment and employ appropriate diagnostic tools. Tracheo-oesophageal fistulas are often associated with respiratory manifestations, even when they have been surgically repaired.

Keywords: Chronic pulmonary aspiration dysphagia. Gastro-oesophageal reflux. Tracheo-oesophageal fistula. Children.

***Correspondence to:**
Joan Figuerola-Mulet
E-mail: joan.figuerola@ssib.es

Received: 05-02-2025
Accepted: 06-03-2025
DOI: 10.23866/BRNRev:2025-M0124
www.brnreviews.com

INTRODUCTION

Pulmonary aspiration is defined as the inadvertent entry of foreign substances into the airway through the vocal cords in a manner sufficient to induce chronic or recurrent respiratory symptoms.

Small aspirations can occur in healthy children, mainly during sleep. They are more frequent in situations of increased nasopharyngeal mucus discharge, such as sinusitis or nasopharyngitis. Due to protective anatomical and physiological mechanisms, foreign material is rapidly expelled by coughing, thus limiting damage to the respiratory tract. When these protective mechanisms fail, aspiration occurs. It can be classified into two types[1]:

- Antegrade aspiration: when it takes place during the swallowing process. The aspirated material can include secretions, saliva, and food in its different textures.

- Retrograde aspiration: the aspirated material comes from the esophagus and episodes of aspiration are related to gastro-esophageal reflux disease (GERD) or laryngeal reflux disease.

Chronic aspiration is a relatively common problem in the pediatric population, its real prevalence difficult to assess. It typically occurs in patients with underlying diseases and may have various causes. Understanding the conditions associated with these disorders is essential to suspecting their existence and adopting a multidisciplinary approach to achieve an accurate diagnosis and appropriate therapeutic management.

PATHOPHYSIOLOGY

To recognize the signs and symptoms associated with the entry of foreign material into the airway, it is essential first to understand the various physiological mechanisms involved in the complex process of swallowing and airway protection.

Swallowing is divided into three phases: the oral phase (voluntary), in which the bolus is prepared and pushed toward the pharynx; the pharyngeal phase (involuntary), where the bolus moves toward the esophagus, traversing the pharynx while preventing passage into the respiratory tract (nasal passages and larynx); and the oesophageal phase, also involuntary, in which the bolus progresses through peristaltic waves and reaches the stomach. A coordinated and synchronized effort of the anatomical structures involved in these phases is required. Mechanisms regulating this coordination include receptors in the upper airway (pharyngeal, laryngeal, and oesophageal) and the brainstem and cranial nerves. These mechanisms ensure safe and effective swallowing.

If these mechanisms fail to coordinate properly and aspiration occurs, respiratory "clean-up" mechanisms are activated, starting with coughing, the primary defense mechanism, followed by immune responses, mucociliary clearance, and phagocytosis[2].

Aspiration episodes can also be related to GERD. The mechanism involves microaspirations caused by gastro-esophageal reflux (GER), which, when coming into contact with the respiratory mucosa, triggers a vagal reflex leading to bronchoconstriction due to acidic

content in the distal esophagus and the release of inflammatory cytokines.

Studies have shown that exposure of the laryngeal mucosa to acid reduces its sensitivity, increasing the risk of aspiration[3].

A third mechanism involved in pulmonary aspiration, primarily related to the aspiration of saliva, should be considered, particularly in children with neurological pathology and sialorrhea or episodes of choking unrelated to ingestion[4].

Finally, chronic aspiration related to a tracheoesophageal fistula (TEF) not associated with esophageal atresia (EA) must always be ruled out. This condition is usually congenital (H-shaped fistula) or secondary to trauma, failed intubation, or previous surgical intervention.

CLINICAL MANIFESTATIONS IN CHILDREN WITH RECURRENT ASPIRATION

Clinical manifestations (Table 1) will depend on the characteristics of the aspiration, the nature and volume of the aspirated material, and the patient's response[5].

Acute manifestations

The most frequent acute manifestation is coughing related to ingestion, a key diagnostic clue that should always be included in the medical history.

It may be accompanied by stridor, hoarseness, wheezing, and, in cases of massive aspiration, respiratory distress and cyanosis.

Table 1. Signs and symptoms of aspiration

Acute manifestations	Acute manifestations
Coughing related to ingestion	Cough
Cough in postprandial periods	Wheezing
Stridor	Crackling
Aphonia	Halitosis
Wheezing	Pontostatural retardation
Respiratory distress	Aversion to food
Cyanosis	

The expulsion of food content through the nose may indicate velopharyngeal insufficiency, which also predisposes to dysphagia and recurrent otitis and/or sinusitis. GERD is characterized by symptoms such as heartburn, abdominal pain, halitosis, or frequent vomiting. From a respiratory perspective, suspicion of aspiration associated with GER should arise when coughing occurs in the postprandial periods, at night, or in the supine position[6].

In neonates and infants, aspiration may present as apnea or even as what is currently referred to as a brief resolved unexplained event.

Chronic manifestations

Cough is the most frequent manifestation of chronic pulmonary aspiration. Coughing might be induced by repeated aspiration episodes, or appear as a symptom of underlying lung diseases such as bronchitis, pneumonia, wheezing episodes, and even pulmonary fibrosis.

Recurrent bronchitis and pneumonia with or without bronchiectasis are characteristic

findings in chronic aspiration. In the neonatal and infant stages, radiological findings are often observed in the upper lobes and bilaterally, while in older children, they usually affect the right lung and the lung bases.

Persistent wheezing episodes and difficult-to-control asthma should always prompt consideration of aspiration, possibly associated with GERD[6].

Chronic aspiration in pediatric patients may also be associated with failure to thrive. Silent aspiration poses a diagnostic challenge. It should be suspected in all patients with chronic pulmonary pathology of unknown cause and with impaired laryngeal sensitivity, whether due to GERD[7], the presence of a nasogastric tube, or underlying neurological conditions. In patients with neurological pathology, a clinical sign to consider is oral aversion[4].

In advanced stages of pulmonary pathology associated with chronic aspiration, pulmonary fibrosis, and interstitial involvement may occur, potentially leading to chronic respiratory failure.

The main respiratory pathologies in which aspiration should be suspected are summarized in Table 2[8].

Table 2. Respiratory pathologies in which aspiration is suspected

Recurrent bronchitis
Repeated pneumonias
Chronic cough
Recurrent laryngitis
Bronchiectasis
Interstitial lung pathology
BRUE
Pulmonary fibrosis

BRUE: brief unexplained event.

CHRONIC ASPIRATION DUE TO OROPHARYNGEAL DYSPHAGIA

Epidemiology

The incidence of chronic pulmonary aspiration secondary to oropharyngeal dysphagia is higher in patients with a history of prematurity and in those with anatomical malformations, central nervous system diseases, and neuromuscular disorders[5]. It is an underdiagnosed condition.

Etiology

Several factors have been associated to swallowing disorders (Table 3)[9].

Pathophysiology

Aspiration due to oropharyngeal dysphagia can be divided into two types:

Basal aspiration

This involves the aspiration of saliva and is often related to the loss of the swallowing reflex. The oral cavity contains abundant bacteria and fungi, which, if aspirated in sufficient quantity, can cause recurrent pneumonia or pulmonary abscesses.

Table 3. Anomalies associated with chronic aspiration due to swallowing disorders

Nasal and oral cavity congenital anomalies	Choanal atresia and choanal stenosis Mucoceles Macroglossia Cleft lip Cleft palate Craniofacial syndromes
Abnormalities of the larynx, trachea, and esophagus	Laryngomalacia Vocal cord paralysis Laryngeal cleft Tracheoesophageal fistula Oesophageal duplication
Anomalies of the great vessels	Vascular rings Double aortic arch
Neurological diseases	Idiopathic cerebral palsy Neuromuscular diseases Myasthenia gravis Muscular dystrophies and myopathies Congenital malformations Brainstem tumors
Respiratory diseases	Bronchopulmonary dysplasia All diseases causing chronic respiratory distress Foreign body aspiration
Infectious diseases	Acute pharyngotonsillar tonsillitis Peritonsillar and retropharyngeal abscesses Epiglottitis CNS infections
Digestive diseases	Gastroesophageal reflux Caustic ingestion
Neoplasia	Linfangioma Hemangioma Papilloma Leiomyoma
Others	Prematurity Rheumatologic diseases External trauma

Aspiration during swallowing

Predysphagic aspiration

Before the pharyngeal phase, this is the most frequent in central neurological alterations. It results from a lack of bolus control during the oral phase or a deficit in the swallowing reflex trigger. Food remnants are insufficient to trigger the swallowing reflex, and those that reach the pharynx penetrate the larynx, which is not yet protected. Failure to initiate sucking and mild labial seal suggests impairment of cranial nerves V and VII. Delayed swallowing and nasopharyngeal penetration are associated with alterations of cranial nerves IX and/or X and are often accompanied by lingual dysfunction in neuropathies of cranial nerve XII.

Aspiration during swallowing

Incomplete closure of the larynx while swallowing can lead to pulmonary aspiration.

This can manifest in two ways:

1. Laryngeal penetration, defined as the appearance of food content in the larynx above the vocal cords, and

2. Aspiration, if it passes below the glottic plane. If there is laryngeal sensitivity impairment, whether due to GERD, a nasogastric tube, or neurological pathology, aspiration can be silent, without the usual defense mechanisms like coughing.

Post-swallowing aspiration

Post-swallowing aspiration occurs after the pharyngeal phase, due to ineffective clearance of food residue in the laryngeal vestibule after swallowing, or from reflux of material from the esophagus (GERD).

Diagnosis

To determine the type of swallowing disorder and its cause, it is essential to assess the safety

of swallowing and oral feeding, as well as the need for dietary modifications or alternative feeding methods. The evaluation should be multidisciplinary, involving specialists in pulmonology, gastroenterology, otolaryngology, nutrition, neurology, occupational therapy, and radiology[10].

A thorough clinical history should identify factors that predispose to swallowing difficulties. Information on the current diet, food texture, method of administration, position, and feeding duration should be obtained. A feeding time longer than 30 min suggests a behavioral feeding issue or ineffective feeding mechanisms in children with predisposing conditions. The presence of stridor or respiratory sounds, changes in color, or respiratory rhythm (hypopneas or tachypnea) during ingestion may suggest aspiration[11].

Complementary examinations

Chest X-ray and computed tomography (CT) scans are often normal, except in cases with complications such as atelectasis, hyperinflation, interstitial patterns, or bronchiectasis.

Instrumental evaluation is recommended for the diagnosis of aspiration. Videofluoroscopic swallow study (VFSS) and fiber-optic endoscopic evaluation of swallowing (FEES) are both currently considered the gold standard in the diagnosis of oropharyngeal dysphagia[11].

VFSS

The VFSS provides information regarding the inability or difficulty in initiating pharyngeal swallowing, aspiration of ingested food, nasopharyngeal regurgitation, and the presence of post-swallowing residue. It also allows for the assessment of the effectiveness of the swallowing therapy used to correct the observed dysfunction.

However, it does not enable quantification of pharyngeal contractility or intrabolus pressure during swallowing, nor does it detect incomplete relaxation of the lower oesophageal sphincter. The radiation dose is relatively low, ranging from 0.2 to 0.85 mSv (a chest X-ray exposes a person to 0.02 mSv of radiation)[12].

FEES

This test is performed by inserting an endoscope through the nasal passage to obtain a pharyngolaryngeal view. It evaluates the anatomy and mobility of the hypopharynx and larynx, secretion management, direct assessment of swallowing function for foods of various textures – both liquids and solids – and the persistence of pharyngolaryngeal residue after swallowing. If laryngeal penetration or aspiration is observed, various maneuvers (position changes, thickening agents) are performed while the bronchoscope remains in position, allowing real-time evaluation of the response to treatment[13].

The study can be supplemented by assessing laryngeal sensitivity using air pulses through the endoscope, showing the correlation between diminished sensitivity and aspiration.

Compared to VFSS, the advantages of FEES include the avoidance of radiation exposure and the need for the patient to swallow a

Table 4. Recommendations for performing of fiber-optic endoscopic evaluation of swallowing and videofluoroscopy swallowing study

FEES	VFSS
Suspicion of laryngeal anatomical abnormalities	Interest in studying the oral or oesophageal phase of swallowing
Assessment of saliva secretion management	Stenosis or nasal obstruction
Assessment of laryngeal sensitivity	Suspicion of anatomical issues in the esophagus
Assessment of fatigue or deterioration of swallowing throughout the intake	Need to observe multiple rapid swallowing sequences
Interest in video feedback for parents or caregivers	
Patients with aversion or rejection of feeding	
Inability to position the patient for fluoroscopy	
Need for follow-up with repeated examinations	

FEES: fiber-optic endoscopic evaluation of swallowing; VFSS: videofluoroscopy swallowing study.

certain quantity of barium, which may prove difficult to achieve. It is a safe procedure for patients of all ages[14], including neonates, with a low incidence of complications[15].

A high concordance has been observed between the results of FEES and VFSS, both for diagnosing aspiration and for therapeutic recommendations[16]. The two examinations provide highly valuable information and should be considered complementary (Table 4)[9]. In some cases, both of them may be performed.

Bronchoscopy and bronchoalveolar lavage have been used to rule out TEFs and confirm the presence of aspiration. Other studies, such as technetium gammagraphy or salivary gland scintigraphy with radionuclides, have been used on a minor scale with highly variable diagnostic outcomes[17].

Treatment

The treatment of oropharyngeal dysphagia aims to ensure the safety of ingestion, maximize oral feeding (whether partial or complete), and allow for adequate nutrition and hydration without the risk of aspiration or pharyngolaryngeal residue. It must be tailored to the specific needs of each patient.

The most common strategies include modifying food textures (e.g., increasing the viscosity of liquids), teaching postures that facilitate swallowing, and adjusting the feeding speed[9]. These strategies do not alter the physiology of swallowing; they only eliminate symptoms or facilitate swallowing. They do not require the active participation of the patient and can be applied to individuals of all ages and cognitive levels. They must be monitored by the patient's caregivers, as well as by physicians, physiotherapists, and speech therapists.

When oral feeding is insufficient or unsafe despite these measures, consideration should be given to nasogastric tube feeding or gastrostomy. In the case of persistent aspiration of saliva, anticholinergics such as glycopyrrolate can be used, or botulinum toxin may be administered to the salivary glands[17].

ASPIRATION DUE TO GERD

GERD is defined as the retrograde movement and passage of gastric contents into the esophagus. GERD has been associated with respiratory manifestations, which often occur without accompanying digestive symptoms.

Epidemiology

The prevalence and incidence of chronic aspirational syndrome secondary to GERD is difficult to assess, as there is no gold standard for its diagnosis and it can be challenging to determine whether the respiratory symptoms are truly attributable to GERD[18].

Pathophysiology of respiratory symptoms caused by GERD

Several mechanisms have been proposed:

1. Direct mechanism or aspiration. Various predisposing factors (Table 5)[9] can cause alterations in the airway defense mechanisms.
2. Indirect mechanism. Distal oesophageal stimuli may trigger or exacerbate cough or bronchoconstriction, as the esophagus and airways share vagal innervation.
3. Respiratory pathology and its treatment may worsen GERD. During coughing episodes, an increase in intrathoracic and intra-abdominal pressure may promote GERD episodes, although there is limited evidence supporting this.

Table 5. Predisposing factors for GER aspiration

Anatomical	Choanal atresia Micrognathia: Pierre-Robin, Goldenhar, Treacher Collins syndromes Macroglossia: Beckwith-Wiedeman syndrome Cleft palate Laryngeal cleft Tracheoesophageal fistula Pharyngeal rings and masses Pharyngeal diverticulum
Neuromuscular	Idiopathic cerebral palsy Vocal cord paralysis X cranial nerve palsy Möebius syndrome Guillain-Barré syndrome Werdnif-Hoffmann syndrome Muscular dystrophies Hydrocephalus Familial dysautonomia Depression of the level of consciousness
Other	Prematurity Bronchopulmonary dysplasia Cricopharyngeal achalasia Tracheostomy Nasogastric tube

Medications frequently prescribed in respiratory diseases, such as bronchodilators, theophylline, and corticosteroids, can favor GERD.

Diagnostic methods

Clinical evaluation

It is crucial to enquire about respiratory manifestations that may result from aspiration –chronic cough, wheezing, dysphonia, asthma, or pneumonia– as well as GERD-related digestive symptoms, although their absence does not exclude chronic aspiration syndrome. It is important to rule out anatomical or neurological abnormalities that may predispose both to GERD and aspiration.

Imaging studies

Chest X-rays are not sensitive for identifying or quantifying aspiration, although findings such as hyperinflation, peribronchial thickening, and atelectasis may support the diagnosis.

The oesophagogastroduodenal transit is neither sensitive nor specific for GERD diagnosis and should only be performed if an anatomical abnormality is suspected.

Multichannel intraluminal impedance with pH monitoring (MII-pH)

This test detects the anterograde and retrograde passage of acidic or non-acidic material, as well as the movement of fluids or air. It has shown a stronger temporal relationship between non-acid reflux episodes and respiratory symptoms[19]. It can detect pharyngeal reflux.

However, a normal MII-pH does not rule out respiratory disease caused by GERD.

Bronchoscopy and markers in bronchoalveolar lavage (BAL)

Macrophage lipid-laden index: The lipid material from gastric content may be phagocytised, and lipid-laden macrophages (LLM) can be detected in BAL by fat staining. Although a semi-quantitative method has been described to assess the severity of severity assessment code (SAC), the percentage of LLM may be elevated in other respiratory conditions, and there is considerable inter-observer variability in sample processing[20].

No single technique for assessing the presence or severity of GERD can confirm or exclude pulmonary aspiration on its own.

Treatment

Dietary measures and lifestyle changes in SAC due to GERD lack rigorous scientific backing. Prokinetic agents have side effects that limit their use in children.

Proton pump inhibitors reduce gastric acid secretion. Their efficacy has been established for esophagitis, but their safety and efficacy for SAC remain unproven. Fundoplication is the procedure of choice for children with severe or persistent respiratory symptoms and aspiration due to GERD, or for those in whom medical treatment has failed. GERD is resolved in nearly all patients, and respiratory symptoms improve in most.

TEF

Epidemiology and classification

TEF is characterized by an abnormal connection between the trachea and esophagus. It occurs along a spectrum of severity and is commonly associated with EA in 90-93% of cases. Its estimated incidence is 1 in 3500-4500 live births.

Pathophysiology

The etiology of TEF is multifactorial, involving genetic, environmental, and epigenetic factors. Among the proposed environmental factors, exposure to exogenous sex hormones, methimazole, pesticides, herbicides, diabetes, and infections of unknown origin during the first trimester of pregnancy have been implicated. Familial recurrence is rare, and most cases are spontaneous, resulting from *de novo* mutations.

Respiratory complications arise from the interaction between anatomical and functional alterations[7].

Tracheomalacia

This condition results from the anteroposterior collapse of the cartilaginous wall, particularly from the intrusion of the posterior tracheal wall into its lumen. It is due to inadequate development of tracheal cartilage and the presence of aberrant myoelastic fibers in the posterior membrane. Clinical manifestations include cyanotic episodes, chronic cough, recurrent lower airway infections, and recurrent or chronic wheezing.

Altered mucociliary clearance

This occurs secondary to narrowing of the tracheal lumen and a reduced number of ciliated cells in the TEF area.

Aspiration

Aspiration can occur due to the presence or persistence of the TEF itself, fistulas in other locations (such as esophagobronchial fistulas), or the association with other malformations, such as laryngeal clefts or the presence of unilateral or bilateral vocal cord paralysis secondary to surgery.

Bronchiectasis

This is the most severe respiratory complication, resulting from recurrent lower airway infections and aspiration.

Altered gastroesophageal motility

This can lead to GER.

Association with other congenital anomalies

Approximately 50% of patients with TEF have other anomalies affecting different organs or systems, giving rise to syndromes such as VACTERL (vertebral anomalies, anal atresia, cardiac defects, TEF, renal anomalies, and limb malformations) and CHARGE (coloboma, cardiac defects, choanal atresia, growth retardation, genital, and ear anomalies). Chromosomal abnormalities such as trisomies 18 and 21 may also be present.

Diagnostic methods

The International Network on EA Working Group on Respiratory Complications has recently published recommendations for the diagnosis and therapeutic management of these patients, focusing on respiratory complications[21].

Evaluation of tracheomalacia

- Flexible bronchoscopy is the gold standard for both diagnosis and assessment of severity. It is also recommended in cases of unexplained wheezing, exercise intolerance, or children with tracheostomy.

- Inspiratory and expiratory chest CT can provide additional information about the airway, lung parenchyma, and pulmonary vascularisation.

- Spirometry typically shows flattening in the early part of the expiratory loop.

Evaluation of recurrent TEF

- Digestive endoscopy and bronchoscopy are the gold standards for diagnosis.

- The instillation of methylene blue through the trachea or esophagus, followed by its appearance on the opposite side, can help confirm the diagnosis.

- Prone or semi-prone oesophagogram with contrast administered under pressure may yield false negatives if oesophageal stenosis is present.

Evaluation of bronchitis and pneumonia

- If the patient presents with a wet cough, anatomical or functional causes should be excluded. A chest CT scan is recommended in the stable clinical phase to assess recurrence and the presence or absence of bronchiectasis. LBA (Bronchoalveolar Lavage) can also be used for microbiological analysis.

- Chest X-ray should be performed in cases of recurrent pneumonia to document findings and assess whether further studies are required.

Evaluation of bronchiectasis

- A thoracic CT scan is indicated if bronchiectasis is suspected, as a chest X-ray may not rule it out.

Evaluation of aspiration

- Flexible or rigid bronchoscopy should be performed to evaluate airway anatomy and to differentiate recurrent TEF from other possible causes, such as fistulas in other locations, unilateral or bilateral vocal cord paralysis, or the presence of a laryngeal cleft.

- Swallowing assessment by VFS.

- Chest X-ray or thoracic CT to assess for pulmonary lesions secondary to aspiration.

Evaluation of cyanosis

- An echocardiogram, angio-CT, magnetic resonance imaging, or catheterization should be performed if there is suspicion of cardiac abnormalities with a right-to-left shunt or suspected vascular rings.

Treatment

Management of TEF[22]

Treatment of TEF consists of surgical separation of the trachea and esophagus by ligation of the fistula.

- In cases with EA, primary anastomosis of the esophageal segments with simultaneous fistula ligation is preferred and typically is performed as soon as possible. For infants with associated severe tracheomalacia, posterior tracheopexy can be performed simultaneously at the time of the EA repair.

- Primary repair may not be possible if the distance between esophageal segments is large. In that case, the first-line option is to delay the repair for 2–9 months to allow for esophageal growth, which often permits primary repair.

- Alternatives to primary repair include esophageal lengthening by traction, interposition of the jejunum or colon, and gastric transposition.

Management of tracheobronchomalacia[23–25]

Tracheobronchomalacia often improves over time, with an increase in tracheal diameter and a reduction in collapsibility. However, this process may take several years.

- Children with severe tracheomalacia and life-threatening episodes may require ventilatory support (e.g., high-flow nasal cannulae, non-invasive ventilation) during the immediate post-operative period or, in some cases, for weeks or months.

- Anterior or posterior aortopexy has been used with satisfactory results.

- Posterior aortopexy, which involves suturing the posterior aspect of the trachea to the anterior longitudinal ligament of the vertebrae, could be considered a definitive treatment. In some centers, it is performed concurrently with fistula surgery, and an active multicenter trial (PORTRAIT study) is underway[6,26].

- Tracheostomy may be required for patients who, despite receiving respiratory support with non-invasive ventilation, continue to experience life-threatening episodes.

- Tracheal stents are rarely used in infants due to issues with size, potential migration, difficulty with removal, and the need for replacement as the child grows. Both silicone and metal stents are available, though there are no significant differences between them[27].

Antibiotic treatment

- Antibiotics should be administered if the child presents with a wet cough or signs of infection in the lower airways. Common pathogens include *Haemophilus influenzae*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Moraxella catarrhalis*,

and treatment with amoxicillin-clavulanic acid is typically recommended.

– Azithromycin can be useful for recurrent infections and bronchiectasis.

Adjuvant treatments

– Respiratory physiotherapy is routinely recommended for both symptomatic and asymptomatic patients. Although there is no conclusive evidence on the most effective techniques, positive expiratory pressure valves are particularly useful in children with tracheomalacia and bronchiectasis.

– Antireflux treatment should be initiated empirically if persistent respiratory symptoms are present, given the high association between GER and TEF.

– Bronchodilators: salbutamol is generally not recommended, as it may exacerbate symptoms by relaxing tracheobronchial smooth muscle. Ipratropium bromide may improve symptoms in children with tracheomalacia and should be considered as a first-line option.

– Inhaled corticosteroids should be prescribed only in cases of airway hyperreactivity.

Other care

– Patients diagnosed with TEF should be managed by a multidisciplinary team, including pulmonologists, gastroenterologists, otorhinolaryngologists, pediatricians, pediatric surgeons, physiotherapists, speech therapists, occupational therapists, and social workers.

– Follow-up should be conducted at least annually throughout childhood and adulthood.

– Annual vaccination against influenza is recommended.

REFERENCES

1. Espitaliera F, Fanousb A, Avivc J, Bassiounyd S, Desutere G, Nerurkarf N, et al. International consensus (ICON) on assessment of oropharyngeal dysphagia. Eur Ann Otorhinolaryngol Head Neck Dis. 2018;135:S17-21.
2. Jadcherla S. Dysphagia in the high-risk infant: potential factors and mechanisms. Am J Clin Nutr. 2016;103:622S-8.
3. De Benedictis FM, Bush A. Respiratory manifestations of gastro-oesophageal reflux in children. Arch Dis Child. 2018;103:292-6.
4. Weir K, McMahon S, Taylor S, Chang A. Oropharyngeal aspiration and silent aspiration in children. Chest. 2011;140:589-97.
5. Bae SO, Lee GP, Seo HG, Oh BM, Han TR. Clinical characteristics associated with aspiration or penetration in children with swallowing problem. Ann Rehabil Med. 2014; 38:734-41.
6. Gaude G. Pulmonary manifestations of gastroesophageal reflux disease. Ann Thorac Med. 2009;4:115-23.
7. Houghton LA, Lee AS, Badri H, DeVault KR, Smith JA. Respiratory disease and the oesophagus: reflux, reflexes and microaspiration. Nat Rev Gastroenterol Hepatol. 2016;13:445-60.
8. Duncan DR, Mitchell PD, Larson K, Rosen RL. Presenting signs and symptoms do not predict aspiration risk in children. J Pediatr. 2018;201:141-6.
9. Osona B, Pastor MD, Gil JA. Complicaciones respiratorias en el niño con trastorno de deglución y/o reflujo gastroesofágico. In: Andrés A, Valverde J, editors. Tratado de Neumología Pediátrica. Madrid: EIOSalud; 2021. p. 1234-47.
10. Adil E, Al Shemari H, Kacprowicz A, Perez J, Larson K, Hernandez K, et al. Evaluation and management of chronic aspiration in children with normal upper airway anatomy. JAMA Otolaryngol Head Neck Surg. 2015;141:1006-11.
11. Cuestas G, Rodríguez V, Bellia Munzón P, Bellia Munzón G. Algoritmo para el manejo de la aspiración pulmonar crónica en pediatría. Arch Argent Pediatr. 2019;117:412-20.
12. Re GL, Vernuccio F, Di Vittorio ML, Scopelliti L, Di Piazza A, Terranova M, et al. Swallowing evaluation with videofluoroscopy in the paediatric population. Acta Otorhinolaryngol Ital. 2019;39:279-88.
13. Langmore S.E. History of fiberoptic endoscopic evaluation of swallowing for evaluation and management of pharyngeal dysphagia: changes over the years. Dysphagia. 2017;32:27-38.
14. Miller CK, Willging JP. Fiberoptic endoscopic evaluation of swallowing in infants and children: protocol, safety, and clinical efficacy: 25 years of experience. Ann Otol Rhinol Laryngol. 2020;129:469-81.

15. Vetter-Laracy S, Osona B, Roca A, Peña-Zarza JA, Gil JA, Figuerola J. Neonatal swallowing assessment using fiberoptic endoscopic evaluation of swallowing (FEES). Pediatr Pulmonol. 2018;53:437-42.
16. Leder SB, Karas DE. Fiberoptic endoscopic evaluation of swallowing in the pediatric population. Laryngoscope. 2000;110:1132-6.
17. Boesch RP, Daines C, Willging JP, Kaul A, Cohen AP, Wood RE, et al. Advances in the diagnosis and management of chronic pulmonary aspiration in children. Eur Respir J. 2006;28:847-61.
18. Trinick R, Johnston N, Dalzell AM, McNamara PS. Reflux aspiration in children with neurodisability--a significant problem, but can we measure it? J Pediatr Surg. 2012;47:291-8.
19. Masiak W, Wallner G, Wallner J, Pedowski T, Solecki M. Combined esophageal multichannel intraluminal impedance and pH monitoring (MII -pH) in the diagnostics and treatment of gastroesophageal reflux disease and its complications. Pol Przegl Chir. 2011;83:488-96.
20. Kelly EA, Parakininkas DE, Werlin SL, Southern JF, Johnston N, Kerschner JE. Prevalence of pediatric aspiration-associated extraesophageal reflux disease. JAMA Otolaryngol Head Neck Surg. 2013;139:996-1001.
21. Krishnan U, Dumont MW, Slater H, Gold BD, Seguy D, Bouin M, et al. The International Network on Oesophageal Atresia (INoEA) consensus guidelines on the transition of patients with oesophageal atresia-tracheoesophageal fistula. Nat Rev Gastroenterol Hepatol. 2023;20: 735-55.
22. Oermann CM. Congenital Anomalies of the Intrathoracic Airways and Tracheoesophageal Fistula. UpToDate; 2024. Available from: ww.uptodate.com/contents/congenital-anomalies-of-the-intrathoracic-airways-and-tracheoesophagealfistula?source=see_link&sectionName=TRACHEOMALACIA&anchor=H11#H11 [Last accessed on 2025 Mar 05].
23. Koumbourlis AC, Belessis Y, Cataletto M, Cutrera R, DeBoer E, Kazachkov M, et al. Care recommendations for the respiratory complications of esophageal atresia-tracheoesophageal fistula. Pediatr Pulmonol. 2020;55:2713-29.
24. Sadreameli SC, McGrath-Morrow S. Respiratory care of infants and children with congenital tracheo-oesophageal fistula and oesophageal atresia. Paediatr Respir Rev. 2016;17:16-23.
25. Bashir A, Krasaelap A, Lal DR, Gourlay DM, Pan AY, Jan N, et al. Esophagitis, treatment outcomes, and long-term follow-up in children with esophageal atresia. J Pediatr Gastroenterol Nutr. 2024;79:1116-23.
26. Van Stigt MJ, van Hal AF, Bittermann AJ, Butler CR, Ceelie I, Cianci D, et al. Does primary posterior tracheopexy prevent collapse of the trachea in newborns with oesophageal atresia and tracheomalacia? A study protocol for an international, multicentre randomised controlled trial (PORTRAIT trial). BMJ Open. 2024;14:e087272.
27. Mo R, Cao J, Zhou J, Bian C. Silicone stent versus fully covered metallic stent in tracheoesophageal fistula: a single-center retrospective study. BMC Pulm Med. 2024;24:612.