Imaging studies in evaluating children with stridor

Giselle Cuestas¹ ☞, Verónica Rodríguez¹ ☞, Patricio Bellia Munzón¹ ☞, Gastón Bellia Munzón² ☞

ABSTRACT

Stridor is a symptom of upper airway obstruction and may result from congenital or acquired causes. The diagnosis is usually clinical. If further investigation is necessary for differential diagnosis, endoscopy is the method of choice in most cases.

Imaging studies are complementary to endoscopy. They allow evaluation of laryngeal and tracheobronchial pathology and extrinsic airway compressions due to tumors or vascular malformations and define a lesion’s location, extent, and characteristics. They are helpful in cases of diagnostic doubt and when endoscopy is unavailable.

It is essential to understand the anatomy and pathophysiology of the respiratory tract and to be aware of the indications and limitations of complementary examinations for proper diagnosis.

The different imaging modalities available to evaluate stridor in pediatrics are described, and their advantages are discussed.

Keywords: diagnostic imaging; radiography; stridor; child.

doi: http://dx.doi.org/10.5546/aap.2024-10328.eng


¹ Respiratory Endoscopy Section, Division of Otorhinolaryngology; ² Surgery Department; Hospital General de Niños Pedro de Elizalde, City of Buenos Aires, Argentina.

Correspondence to Giselle Cuestas: giselle_cuestas@yahoo.com.ar

Funding: None.

Conflict of interest: None.

Received: 1-25-2024
Accepted: 5-6-2024

This is an open access article under the Creative Commons Attribution–Noncommercial–Noderivatives license 4.0 International. Attribution - Allows reusers to copy and distribute the material in any medium or format so long as attribution is given to the creator. Noncommercial – Only noncommercial uses of the work are permitted. Noderivatives - No derivatives or adaptations of the work are permitted.
INTRODUCTION

Stridor is respiratory noise caused by partial airway obstruction at the larynx, trachea, and main bronchus levels. The obstruction may be fixed or dynamic and includes congenital, inflammatory, neoplastic, and traumatic pathology.1-3 The stridor is inspiratory when the obstruction is supraglottic or glottic, biphasic when it is fixed subglottic, and expiratory when it is intrathoracic.3,4

Evaluating a child with stridor involves a detailed anamnesis and physical examination, which can guide the diagnosis with a high degree of accuracy. Should the stridor be of unusual course or present with apneas, cyanosis, feeding difficulty, respiratory distress, and respiratory failure, direct airway visualization by endoscopy is necessary and is the gold standard for definitive diagnosis of stridor. Imaging studies are complementary to clinical and respiratory endoscopy.

The appropriate choice of diagnostic modalities requires consideration of the risks and benefits of each procedure along with the clinical scenario.5 Endoscopy under local anesthesia (with flexible fiberoptics) allows assessment of laryngeal dynamics, visualization of the supraglottis, and chordal mobility. If symptoms are severe or pathology below the vocal cords is suspected, endoscopy is performed under general anesthesia (with rigid or flexible instrumentation), which allows evaluation of the larynx, trachea, and main bronchi and their segmentation.2

Endoscopy requires specialized personnel and equipment and is not always available. It is invasive, and the child’s uncooperativeness may result in inadequate visualization of the larynx.6 The procedure itself or the use of anesthesia may be associated with adverse effects such as hypoxia, hypercapnia, and laryngospasm.7 Consequently, attention has turned to less invasive diagnostic methods. Imaging studies make it possible to determine the site of obstruction, define the location, extent, and characteristics of a lesion, evaluate extrinsic airway compressions from tumors or vascular malformations, and examine narrow airways that are difficult to visualize by endoscopy.2,3

Although more sophisticated studies are now available, radiography maintains a role in helping to identify the cause of stridor; it is the initial test of choice in pediatric patients.8 Lateral neck radiograph helps reveal structural pathology in the child with inspiratory or biphasic stridor, while the barium swallow allows identification of pathology causing extrinsic tracheal compression in children with expiratory stridor. Other imaging studies are used in selected cases.

The different imaging modalities available to evaluate stridor, their benefits, and limitations are described (Table 1).1,3,6,9-13

PLAIN RADIOGRAPHY

Plain neck and chest radiographs can establish the location and nature of an airway obstruction. A neck radiograph is helpful for soft-tissue assessment, especially a lateral projection.14 It can quickly, safely, and inexpensively identify airway injuries (Figure 1).4

It should be requested using the soft tissue technique (low kilovoltage), with the neck in hyperextension and inspiration.9,14 During expiration, the trachea narrows and deviates anteriorly, which may give a false impression of retropharyngeal thickening.14,15 In the frontal view, the infant’s trachea is displaced to the right due to the aortic arch, which may simulate a mediastinal lesion.8,15 Knowledge of the normal anatomy is necessary to identify an abnormality and must be interpreted in the context of history, physical examination, and diagnostic suspicion.1,8

The diagnosis of croup and epiglottitis is clinical, and complementary examinations are not usually necessary.3 An anteroposterior neck radiograph in a child with croup may show the typical symmetric progressive narrowing of the subglottis and cervical trachea with the apex at the glottis (bell jar sign). In epiglottitis, the lateral neck radiograph shows edema of the epiglottis (thumb sign) and thickened aryepiglottic folds.1,8,14

If the patient is positioned appropriately, the anteroposterior width of the retropharyngeal soft tissue should be less than the anteroposterior width of the cervical vertebra.14 Lymphadenopathy and abscesses can lead to retropharyngeal thickening and cause airway obstruction. It is essential to evaluate for the presence of an ingested foreign body (FB), which may be the cause of the infection.14 Radiography is sufficient to identify thickening; however, defining the precise cause requires other studies (ultrasound, magnetic resonance imaging [MRI], or computed tomography [CT] with contrast).8

Other obstructive lesions that may be detected include cysts, stenosis, laryngeal membrane, and subglottic hemangioma. The diagnosis is usually confirmed by endoscopy.8 In the case of extrinsic masses compressing the airway (cysts,
neoplasms, lymphadenopathy), CT or MRI are necessary to evaluate them.

Laryngomalacia is the most frequent cause of inspiratory stridor in children under six months of age. Its typical radiographic findings consist of downward and posterior flexion of the epiglottis and shortening of the aryepiglottic folds. However, most are not diagnosed with radiography, as malacia is a dynamic phenomenon and radiography presents a static image. The clinical diagnosis is confirmed with flexible fibroscopy under local anesthesia.

Chest radiography is indicated to evaluate the lungs and cardiac size and to help exclude the presence of a FB.

In the presence of suspected FB, neck and chest radiographs can help identify the location, type, and number of FB.

### Table 1. Benefits and limitations of different imaging modalities in the evaluation of the child with stridor

<table>
<thead>
<tr>
<th>Modality</th>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain radiograph</td>
<td>Wide availability. It is low-cost. Does not require sedation. Useful to locate the lesion and rule out different pathologies.</td>
<td>Radiation exposure. Several factors (patient position, crying, radiological technique, and respiratory phase) can significantly alter the appearance of the airway, leading to misinterpretation.</td>
</tr>
<tr>
<td>Fluoroscopy</td>
<td>Non-invasive, easy to perform, and fast. Identifies dynamic lesions of the airway and evaluates multiple sites of obstruction simultaneously. Useful when there is difficulty in obtaining radiography (lack of cooperation).</td>
<td>Radiation exposure. Poor sensitivity.</td>
</tr>
<tr>
<td>Contrast studies of the gastrointestinal tract</td>
<td>Wide availability. Does not require sedation. Evaluates structural or functional abnormality from the oral tract to the gastroesophageal junction. Provides a dynamic investigation of swallowing (can detect aspiration and reflux).</td>
<td>Radiation exposure. The cause of stridor can be inferred by esophageal indentation patterns, but vascular structures or masses are not seen.</td>
</tr>
<tr>
<td>Bronchography</td>
<td>Useful to evaluate congenital tracheobronchial malformations, dynamic or fixed bronchial obstructions, and bronchial patency beyond endoscopic visibility.</td>
<td>Radiation exposure. Need for general anesthesia. Risk of respiratory obstruction.</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Non-invasive, radiation-free, and well tolerated, with no need for sedation. Allows dynamic and anatomical evaluation of the larynx.</td>
<td>Operator-dependent. Lack of experience in the evaluation of the larynx. Limited usefulness in evaluating the thorax and mediastinum (except for a lesion in the superior mediastinum).</td>
</tr>
</tbody>
</table>
Radiologic investigation can confirm an FB aspiration but should not be used to exclude it, as most of the FBs in the airway are radiolucent (food, plastic). Showing a radiopaque object or indirect signs, such as obstructive emphysema, atelectasis, or consolidation, may be expected. However, rigid endoscopy under general anesthesia is the best diagnostic and therapeutic method.

Occasionally, a FB in the esophagus may cause respiratory symptoms when compressing the trachea. Plain radiography can confirm the diagnosis, as most of the ingested FBs are radiopaque. It is essential to differentiate a coin (the most common FB) from a button cell because of the early damage that the battery can cause4,17 (Figure 2).

**FLUOROSCOPY**

Fluoroscopy shows organs and internal structures in motion in real-time. Inspiratory and expiratory airway fluoroscopy allows multiple sites of obstruction to be assessed simultaneously and to identify dynamic lesions such as tracheomalacia.4

Due to its high specificity, it can be applied in suspected FB, stenosis, and airway masses. However, its sensitivity is low.3,5 A negative result requires further evaluation, which, added to radiation exposure, makes its value as a diagnostic tool uncertain.5

**CONTRAST STUDIES**

Barium swallow helps evaluate the child with stridor, especially with an expiratory component, to identify pathologies that cause extrinsic tracheal compression, which usually has a vascular origin; less frequent are tumors, cysts, heart disease, and abscesses (Figure 3).3,9,10,18 Esophageal patterns of indentation can infer the cause.1 Vascular rings are congenital anomalies of the aortic arch and branches that compress the trachea and esophagus to varying degrees. Symptoms appear in the first months of life with biphasic or expiratory stridor and respiratory distress. In the double aortic arch, bilateral curvilinear lateral indentations are seen in the frontal view of the esophagus. The lateral projection shows the pulmonary artery sling as an anterior notch of the upper esophagus. In
tracheal compression by the innominate artery, the esophagogram is normal.\textsuperscript{1,18}

Performing endoscopy and barium swallow to identify extrinsic compression will depend on access to these procedures and the treating professional team.

In the case of a radiolucent FB impacted in the esophagus, a repletion defect producing the object can be observed in the barium swallow.\textsuperscript{1,8,17} Also, contrast studies (serial esophagogastroduodenal or swallowing videofluoroscopy) can detect gastroesophageal reflux (can cause or contribute to stridor) and laryngeal cleft. The latter results from failure of fusion of the posterior cricoid lamina and tracheoesophageal septum, resulting in the passage of contrast from the esophagus to the larynx and trachea. An endoscopy will confirm the diagnosis.\textsuperscript{1}

Bronchography is a radiographic examination that involves introducing into the tracheobronchial tree a water-soluble contrast substance that makes the bronchi visible and allows even the finest distributions to be seen. It is performed with tracheobronchoscopy, which evaluates congenital tracheobronchial malformations (micro trachea), bronchial obstructions, bronchial patency beyond endoscopic visibility, and bronchial fistulas.

**COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING**

They allow evaluation of the location and extent of cervical or thoracic masses, cardiovascular anomalies compressing the airway, and delineation of cysts, laryngoceles, and abscesses.\textsuperscript{3,4,11,19}

MRI is excellent in evaluating cervical, mediastinal, and chest wall masses (of tumor or vascular origin) but is of little use in evaluating the airway and lung parenchyma. CT is currently the most widely used imaging method to assess the airway. It allows the evaluation of the airway wall and adjacent tissues and reconstructions. CT is requested to specify the region (neck and thorax) according to the presumptive diagnosis.

In the initial evaluation of the child with the suspected vascular ring, esophagogram and endoscopy are helpful, but the tests that confirm the diagnosis are angiotomography or angioresonance, which determine the cause of compression and provide the surgeon with the information to proceed with surgical correction, if necessary. Unlike angiography, they are
noninvasive and allow differential diagnosis with other causes of extrinsic airway compression: mediastinal tumors, bronchogenic cysts, and hemangioma, among others.\textsuperscript{18}

Real-time dynamic laryngeal MRI (cine-MRI) can image moving structures. It can detect dynamic processes such as reduced chordal mobility, tracheomalacia, or pulsatile compression. This technique requires full cooperation, without the influence of anesthetics, so its implementation in pediatrics is rare.\textsuperscript{12}

CT is the method of choice to evaluate laryngeal fractures.\textsuperscript{19} It is also indicated in complex cases of FB aspiration (e.g., suspected complication, residual FB after bronchoscopy). It allows the FB to be evidenced, whether radiolucent or radiopaque.\textsuperscript{14}

CT with intravenous contrast is used to
delineate the extent of abscesses and evaluate complications. In the patient with hemangioma, the well-demarcated soft tissue mass is enhanced with contrast. The hemangioma may be even more evident on MRI with classic very bright T2 signal intensity.

Computer-assisted image reconstruction has enabled three-dimensional (3D) airway reconstruction, which helps assess the extent and severity of the obstruction and the relationship to adjacent structures and planning surgical intervention.

In recent years, the use of virtual CT endoscopy has been described. It can provide a noninvasive endoscopic evaluation simulation but not replace conventional laryngotracheobronchoscopy. It helps detect fixed airway lesions and helps to visualize the distal portion in cases of total obstruction. However, it has limitations in evaluating dynamic obstruction, does not provide information on mucosal quality (cicatricial vs. inflammatory), and can lead to artifacts due to mucus retention distal to the obstruction.

ECOGRAPHY

Ultrasonography is the first method to evaluate possible cervical lesions; conversely, it is not indicated in thoracic pathology.

Laryngeal ultrasound is a new diagnostic tool that has proven helpful in specific abnormalities that cause stridor, mainly in neonates.

It allows dynamic and anatomical evaluation of the larynx. It has been used to diagnose chordal palsy (the affected vocal cord is observed immobile or moving medially in inspiration) and evaluate space-occupying lesions. It can determine whether the mass is solid (tumor, adenopathy) or cystic (abscess) and is helpful in the follow-up of subglottic masses, such as hemangioma, after treatment with propranolol. It can also confirm endotracheal intubation and guide cricothyroidotomy. Despite its advantages, laryngeal ultrasound needs to be more utilized. As more experience is gained, its value in evaluating stridor will be better understood.

CONCLUSIONS

Evaluating the patient with stridor requires knowledge of the benefits and limitations of available tests to diagnose accurately with methods that pose the least potential risk to children. If there is no perceived benefit, any radiation, however small, is unwarranted and can contribute to the development of malignancy in the late pathway.

Plain radiography can delineate the site of obstruction and aid in diagnosis. Other imaging modalities are used in selected cases.

Interpretation of imaging should correlate with history and physical examination. Caution and good clinical judgment are essential.

REFERENCES
