The role of radiology in the evaluation of stridor

T R Goodman, K McHugh

Stridor is a medium pitched respiratory noise caused by partial obstruction of the large airways at the level of the pharynx, larynx, and/or trachea (usually the extrathoracic trachea). Stridor is characteristically heard on inspiration, but can be expiratory or biphasic if the obstructive lesion is more distal. Understanding its causes and being aware of the indications and limitations of the various imaging modalities available for its assessment are vital if the condition is to be investigated appropriately. Children and neonates are particularly susceptible to stridor because their immature airways are much more compliant than those of an adult and, therefore, are more prone to collapse. Furthermore, the diameter of a child’s airway is so small that only a slight reduction in diameter causes a considerable reduction in cross-sectional area. For example, in a typical 1–2 year old child with a tracheal diameter of 6.5 mm, a circumferential increase in wall thickness of only 1 mm will reduce the cross-sectional area by more than half.

Stridor can be divided into an acute or subacute/chronic type of presentation. Acute stridor develops over hours and is a critical condition requiring immediate assessment and treatment. In cases of this type, time consuming and complex imaging investigations are unnecessary because the causes of this condition are limited, and can usually be diagnosed on clinical grounds alone. However, imaging can play a valuable role in accurately determining the underlying causes of subacute or chronic stridor that develop over days or weeks. Table 1 shows the different types of stridor presenting at different ages. The various imaging modalities available for the assessment of stridor will be described and their merits discussed.

Plain radiography

Plain radiographs have no role to play in the assessment of the critically ill child with acute stridor. Fibreoptic endoscopic examination of the airway is the investigation of choice and must be performed in the presence of personnel who are equipped and able to perform rapid intubation. In this way, the diagnosis can be made and intubation facilitated at the same time if deemed necessary. In particular, radiographs should not be performed in patients in whom epiglottitis is likely because sudden and catastrophic airway obstruction can occur. However, all paediatricians and radiologists should be able to recognise the swollen epiglottis of acute epiglottitis. Lateral films show the characteristically thickened epiglottis (fig 1). The aryepiglottic folds are also thickened, but the vocal cords and subglottic trachea are usually normal.

In less critical cases, or in situations where fibreoptic endoscopy is not available, a frontal and lateral low kV (to accentuate the soft tissues) radiograph of the neck might be helpful. In these less critical cases, chest radiographs are definitely indicated to assess the lungs and cardiac size, as well as helping to exclude a radio-opaque foreign body. A normal frontal and lateral chest radiograph has also been shown virtually to exclude the diagnosis of a vascular ring as a cause of stridor. In a group of 41 children with a surgically confirmed vascular ring, Pickhardt et al found that every patient had at least one abnormality on the frontal or lateral chest radiograph.7

Because plain radiographs of the upper airway are occasionally performed, a sound appreciation of the normal anatomical appearances is required to identify any abnormalities present. On a lateral radiograph of the upper airway taken on inspiration, the oropharynx, nasopharynx, and uvula separating the two can be clearly appreciated. The epiglottis is seen as a thin soft tissue density extending posteriorly

Table 1 Causes of acute and subacute/chronic stridor in relation to age

<table>
<thead>
<tr>
<th>Age</th>
<th>Acute</th>
<th>Subacute/Chronic</th>
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<tbody>
<tr>
<td>&lt; 2 years</td>
<td>Epiglottitis</td>
<td>Laryngeal causes</td>
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<td>Aspiration</td>
<td>Laryngotracheobronchitis</td>
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<td>Laryngotracheobronchitis</td>
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<td>Vocal cord palsy</td>
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<td>2–5 years</td>
<td>Epiglottitis</td>
<td>Tracheal causes</td>
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<td>Laryngotracheobronchitis</td>
<td>Tracheomalacia</td>
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<tr>
<td></td>
<td>Angioneurotic oedema</td>
<td>Subglottic stenosis</td>
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<td></td>
<td>Bacterial tracheitis</td>
<td>Haemangioma</td>
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<tr>
<td>&gt; 5 years</td>
<td>Angioneurotic oedema</td>
<td>Cystic hygroma</td>
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<td></td>
<td>Vascular ring</td>
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<td></td>
<td>Tracheo-oesophageal fistula</td>
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<td>Quinoid/trocharanegal abscess</td>
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<td>Laryngeal papilloma</td>
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<td>Oesophageal foreign body</td>
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<td></td>
<td>Tubregulanoma</td>
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<td></td>
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<td>Tonsillar hypertrophy</td>
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<td></td>
<td></td>
<td>Vascular rings</td>
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<td>Subglottic/tracheal stenosis</td>
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<td>Pharyngitis</td>
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<td>Laryngeal papilloma</td>
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from the back of the tongue above the level of the hyoid bone. The vallecula is the space formed between it and the anterior hyoid bone. The aryepiglottic folds connect the lateral aspect of the epiglottis to the arytenoid cartilages and are seen as thin linear densities passing inferoposteriorly from the epiglottis. The false cords, ventricle, and true cords are positioned in descending order above the subglottic trachea. Normally, a lateral neck radiograph taken on inspiration shows the hypopharynx distended with air, the epiglottis in a vertical position, and the aryepiglottic folds stretched diagonally. Artefacts in radiographs of normal airways can be produced by bad positioning—that is, neck flexion or poor exposure technique. On the frontal view the glottis should generally be as wide as the trachea.

In croup (laryngotracheobronchitis), the most common cause of acute stridor, glottic airway obstruction is caused by swelling that extends over a variable distance inferiorly to involve the subglottic trachea. On lateral neck radiographs in patients with this condition, the supraglottic airway is generally overdistended with air, the glottic region is indistinct as a result of oedema, the aryepiglottic folds are stretched, and there is variable narrowing of the subglottic cervical trachea (fig 2). This region is particularly prone to narrowing because the loosely attached mucosa allows submucosal oedema to occur readily. On the frontal view, the “steeple” or “funnel” configuration of the oedematous glottic and subglottic regions might occasionally be seen, as opposed to the normal rectangular appearance, although this is a notoriously unreliable sign.

Radiology is unreliable in the diagnosis of laryngomalacia. Although the diagnosis can occasionally be suggested by radiographs showing buckling or shortening of the aryepiglottic folds, the definitive diagnosis can only be made during laryngoscopy.

**Fluoroscopy**

Fluoroscopy during inspiration and expiration is a useful investigation that is fast, easy to perform, and probably underutilised in the assessment of tracheomalacia. Tracheomalacia is caused by an immaturity and deficiency of the cartilaginous components of the trachea, and can be a primary congenital condition, or can be secondary to any condition that has resulted in compression of the trachea for a prolonged period of time. One of the most common causes of the secondary type is oesophageal atresia, where the compressive effects are caused by the dilated proximal oesophageal pouch. Other causes include a double aortic arch, pulmonary artery sling, or a mediastinal mass. During fluoroscopy, the intrathoracic trachea is seen to collapse on expiration, either focally or throughout its length.

**Upper gastrointestinal (GI) contrast studies**

Although not used as a first line investigation in the child with stridor, upper GI contrast studies can be useful in suggesting a cause. Certain conditions, such as an H type tracheoesophageal fistula or a non-radio-opaque impacted oesophageal foreign body, can be confidently diagnosed by means of an upper GI contrast study. Other conditions may be inferred by demonstrating various patterns of oesophageal indentation caused by extrinsic masses. For example, the most common extrinsic compressive disorder causing stridor is a double aortic arch, which is the result of the persistence of both embryological fourth aortic arches. On a frontal view of a contrast filled oesophagus this is seen as bilateral lateral curvilinear indentations at the level of T4. A pulmonary artery sling or aberrant left pulmonary artery causes stridor by compressing the right main bronchus and lower trachea, and gives a characteristic anterior indentation of the upper thoracic oesophagus on the lateral projection (fig 3). This finding is virtually
pathognomonic, although an aberrant subclavian
artery might also rarely give this appearance. A
posterior laryngeal cleft is an important condi-
tion that can also be detected on a contrast
study. This condition is the result of a failure of
the posterior cricoid lamina and tracheo-
esophageal septum to fuse, which results in a
cleft of variable severity and extent originating
in the interarytenoid region. This gives rise to
contrast spilling from the oesophagus into the
larynx and trachea. Distinguishing this from
simple aspiration, another cause of stridor, can
be difficult and endoscopy should, of course,
be used to confirm the defect.

Computed tomography and magnetic
resonance imaging
Cross sectional imaging techniques are most
useful in confirming extrinsic compression of
the airways. A large proportion of the most
common extrinsic causes of stridor (retropha-
ryngeal masses, inflammation, supraglottic,
and glottic/subglottic masses) require com-
puted tomography (CT) or magnetic reso-
nance imaging (MRI) for confirmation of the
diagnosis. In addition, these modalities pro-
vide vital information about the extent of
involvement by masses, such as haemangi-
omas, in the surrounding soft tissues; a feature
that cannot be appreciated on endoscopic
analysis alone. Retropharyngeal soft tissue
swelling is best assessed by CT or MRI. Both
modalities yield similar information although,
when available, MRI is preferable mainly
because it does not use ionising radiation.
The administration of contrast agents in
inflammatory conditions can accurately detect
any surgically drainable fluid collection.

Because of its multiplanar and flow sensitive
imaging capabilities MRI is excellent for the
investigation of suspected vascular rings, which
can cause stridor. It is superior to angiography
because airways and vessels are imaged simul-
taneously. In certain cases, it has also been
shown to be superior to echocardiography
because airways and vessels are imaged simultane-
ously. However, it does have the disadvantage of
requiring complete immobilisation of the child,
possibly for up to 60 minutes. This usually
necessitates sedation or general anaesthesia,
which can be problematic in patients with stri-
dor. It should be used as a second line investi-
gation where plain films and echocardiography
have not determined the cause, but have
suggested a vascular anomaly. Using T1
weighted spin echo sequences with contiguous
thin sections with cardiac gating, excellent
definition of vessels and airways is achieved (fig
4). So called cine or gradient echo sequences
can also be utilised; these make flowing blood
appear white, in contrast to the black lack of
signal returned by air within the airways. Not
only can MRI detect the more common causes
of vascular compression, such as a double aor-
tic arch or pulmonary artery sling, but it has
also been shown to be diagnostic in less
common conditions, such as pulmonary artery
aneurysmal dilatation. Recent advances in
MRI, particularly in echoplanar imaging with
ultrafast image acquisition, are likely to make
MRI an even more important imaging modal-
ity for stridor in selected cases in the future.

Ultrasound
Sonography of the larynx is a new diagnostic
tool that has been shown to be useful in deter-
mining abnormalities that can cause stridor,
particularly in neonates. Despite air reflecting

Figure 3  (A) Lateral view of a barium swallow showing anterior indentation of the oesophagus by a soft tissue mass
(asterisk). Contrast enhanced computed tomography (B) confirmed a pulmonary artery sling (arrow).

Figure 4  T1 weighted, spin echo coronal magnetic
resonance imaging showing a trachea (short arrow) with
distal narrowing as a result of compression by a double
aortic arch (long arrow).
sound waves, laryngeal anatomy can be visualized using a high frequency linear array ultrasound probe at the level of the false cords and below.10 This technique has the advantage over plain films because certain soft tissue masses, such as cystic hygromas, have characteristic ultrasound appearances. It is also a non-invasive test that allows dynamic assessment of the vocal cords. Although ultrasound is somewhat operator dependent in this context, vocal cord palsy can be diagnosed, with the affected cord being immobile or moving medially on inspiration. Ultrasound may also have potential uses in the follow up of subglottic masses, such as haemangiomas subsequent to steroid or interferon treatment. This is particularly important because the subglottic area is notoriously difficult to assess via endoscopy.11

Conclusion
When severe airway obstruction is present in the child with acute stridor, radiography can cause undue delay in treatment and should be avoided. In milder cases if anteroposterior and lateral films of the neck are taken then the normal anatomical appearances should be understood. However, clinical assessment is of the utmost importance in these conditions, and over reliance on plain radiographs can be misleading.

In all children with non-acute stridor, frontal and lateral chest films should be taken to exclude recurrent aspiration or a vascular ring. With a suspected vascular ring, local experience and expertise influence the radiological investigations. MRI is the best modality to confirm a suspected vascular ring and a compressed airway. Dynamic contrast enhanced, preferably spiral, CT or an upper GI contrast study are alternatives, particularly when access to good paediatric MRI is not possible. All patients should also have echocardiography to search for associated cardiac lesions.

With normal chest radiographs, endoscopy should be the next investigation. Neck radiographs, although useful at identifying mass lesions such as subglottic cysts, are frequently unhelpful and are probably best reserved for selected cases according to the endoscopic findings.12 The role of upper GI contrast studies has diminished in recent years with the advent of good cross sectional imaging. These are useful as a fast and inexpensive technique to exclude a diagnosis of a vascular ring when there is a low clinical suspicion. When there is a strong suspicion of gastro-oesophageal reflux, or this diagnosis needs to be excluded, a contrast study is, of course, justifiable.

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