CURRENT TOPIC

The role of radiology in the evaluation of stridor

T R Goodman, K McHugh

Department of
Radiology, John
Radcliffe Hospital,
Oxford OX3 9DU, UK
T R Goodman

Department of
Radiology, Great
Ormond Street
Hospital for Children,
London WC1N 3JH,
UK
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,¹ 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.²

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

Age	Acute	Subacute/Chronic
< 2 years	Epiglottitis	Laryngeal causes
	Aspiration	Laryngotracheobronchitis
	Laryngotracheobronchitis	Laryngomalacia
2–5 years		Laryngeal web
		Laryngeal cleft
		Vocal cord palsy
		Tracheal causes
		Tracheomalacia
		Subglottic stenosis
		Haemangioma
		Cystic hygroma
		Vascular ring
		Tracheo-oesophageal fistula
	Epiglottitis	Laryngotracheobronchitis
	Laryngotracheobronchitis	Quinsy/retropharyngeal abscess
	Foreign body aspiration	Laryngeal papilloma
	Angioneurotic oedema	Oesophageal foreign body
	Bacterial tracheitis	TB/granuloma
> 5 years		Tonsillar hypertrophy
		Vascular rings
		Subglottic/tracheal stenosis
	Angioneurotic oedema	Laryngitis
		Pharyngitis
		Laryngeal papilloma

Figure 1 Lateral neck radiograph showing the thickened epiglottis (thin arrow) and aryepiglottic folds (thick arrow) of acute epiglottitis.

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.³ On the frontal view, the “steeples” 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.⁴

Fluoroscopy

Fluoroscopy during inspiration and expiration is a useful investigation that is fast, easy to perform, and probably underutilised in the assess-

Figure 2 Lateral neck radiograph showing the overinflated supraglottic airway and the oedematous narrowed subglottic trachea of croup (arrow).

ment 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.⁵

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 tracheo-oesophageal fistula or a non-radio-opaque impacted oesophageal foreign body, can be confidently diagnosed by means of an upper GI contrast study.⁴ 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

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).

pathognomic, although an aberrant subclavian artery might also rarely give this appearance.⁶ A posterior laryngeal cleft is an important condition that can also be detected on a contrast study. This condition is the result of a failure of the posterior cricoid lamina and tracheo-oesophageal 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.⁷

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 (retropharyngeal masses, inflammation, supraglottic, and glottic/subglottic masses) require computed tomography (CT) or magnetic resonance imaging (MRI) for confirmation of the diagnosis.⁵ In addition, these modalities provide vital information about the extent of

involvement by masses, such as haemangiomas, 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 of 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 simultaneously. In certain cases, it has also been shown to be superior to echocardiography.⁸ 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 stridor. It should be used as a second line investigation 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 aortic arch or pulmonary artery sling, but it has also been shown to be diagnostic in less common conditions, such as pulmonary artery aneurysmal dilatation.⁹ Recent advances in MRI, particularly in echoplanar imaging with ultrafast image acquisition, are likely to make MRI an even more important imaging modality 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 determining abnormalities that can cause stridor, particularly in neonates. Despite air reflecting

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 visualised 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.

- 1 Kilham H, Gillis J, Benjamin B. Severe upper airway obstruction. *Pediatr Clin North Am* 1987;34:1-14.
- 2 Pickhardt PJ, Siegel MJ, Gutierrez FR. Vascular rings in symptomatic children: frequency of chest radiographic findings. *Radiology* 1997;203:423-6.
- 3 Cressman WR, Myer CM. Diagnosis and management of croup and epiglottitis. *Pediatr Clin North Am* 1994;41:265-76.
- 4 Zalzal GH. Stridor and airway compromise. *Pediatr Clin North Am* 1989;36:1389-402.
- 5 John SD, Swischuk LE. Stridor and upper airway obstruction in infants and children. *Radiographics* 1992;12:625-43.
- 6 Park SC. Vascular abnormalities. *Pediatr Clin North Am* 1981;28:949-55.
- 7 Mancuso RF. Stridor in neonates. *Pediatr Clin North Am* 1996;43:1339-56.
- 8 Beekman RP, Beek FJA, Hazekamp MG, et al. The value of MRI in diagnosing vascular abnormalities causing stridor. *Eur J Pediatr* 1997;156:516-20.
- 9 Ditchfield MR, Culham JAG. Assessment of airways compression by MR imaging in children with aneurysmal pulmonary arteries. *Pediatr Radiol* 1995;25:190-1.
- 10 Friedman EM. Role of ultrasound in the assessment of vocal cord function in infants and children. *Ann Otol Rhinol Laryngol* 1997;106:199-209.
- 11 Garel C, Hassan M, Legrand I, et al. Laryngeal ultrasonography in infants and children: pathological findings. *Pediatr Radiol* 1991;21:164-7.
- 12 Tostevin PMJ, De Bruyn R, Hosni A, et al. The value of radiological investigations in pre-endoscopic assessment of children with stridor. *J Laryngol Otol* 1995;109:844-8.