Wheeze

Wheeze is a continuous, musical, whistling-like abnormal breath sound that is usually heard in expiration. It is a common respiratory symptom and sign in children and adults; the 1958 British National Cohort study found the cumulative incidence of wheezing illness by age 33 to be 43% (Strachan et al, 1996). This article considers wheeze only in adults.

The sound of wheeze derives from partially obstructed and vibrating lower airways and is classically seen, in both clinical practice and postgraduate examinations, in patients with obstructive lung diseases such as asthma, chronic obstructive pulmonary disease or bronchiectasis (Hopkin, 2012). The nature of the wheeze sound heard depends on the calibre of the partially obstructed airway, the velocity of air passing through it, the presence of airway secretions, the state of the lung tissue, and the composition of the chest wall.

The ability to hear wheeze also depends on the listening apparatus used. Sounds with a frequency of between 20 and 20 000 Hz and an appropriate sound pressure are audible to healthy adult humans; work to define the acoustic basis of wheeze has shown it is a sinusoid wave with a duration typically >80 ms and a frequency range that extends from less than 100 Hz to more than 1 kHz (Pasterkamp et al, 1997). Wheeze of the appropriate frequency and intensity is therefore heard without the aid of a stethoscope and may be reported by patients.

Placing the ear against the chest wall, as in direct auscultation, or using an aid such as a stethoscope or electronic sensor, permits greater opportunity for wheeze to be observed. When using a stethoscope it should be remembered that the sound heard has been modified by transmission through the chest wall and along the stethoscope. Stethoscopes tend to amplify sounds below around 100 Hz and to attenuate higher frequencies (Abella et al, 1992). Amplification at low frequencies is appreciated by cardiologists because heart sounds are in this frequency range and are poorly perceived by the human ear. Lung sounds tend to occupy a higher frequency range and a more faithful representation of sound than that typically offered by conventional stethoscopes could be of benefit to the respiratory physician (Pasterkamp et al, 1997).

After inventing the stethoscope in 1816 Lannec described wheeze in his 1819 treatise on auscultation as a dry hiss or whistle-like rattle (*râle sibilant sec ou sifflement*) (Loudon and Murphy, 1984). A standardized international nomenclature of lung sounds proposed by the International Lung Sounds Association in 1985 described wheeze as a continuous high-pitched lung sound, as distinct from rhonchus which is a continuous low-pitched sound (Mikami et al, 1987).

The rationale for making the distinction between wheeze and rhonchus is that the higher pitch of wheeze corresponds to obstruction of smaller peripheral airways whereas rhonchus corresponds to obstruction of larger central airways. However, this is likely to be a simplification because the pitch of wheeze is not determined by the diameter of the airway but by the thickness of the airway wall, its bending stiffness and its longitudinal tension (Gavriely et al, 1989). Unfortunately, the term suffers from ambiguity and imprecision in routine clinical practice and work towards a standard acoustic definition of wheeze is ongoing (Bohadana et al, 2014).

Clinical anatomy and pathophysiology

Wheeze may result from partial obstruction of the airway at any level of the respiratory tract (*Figure 1*). The noise is thought to result from fluttering of the airway wall (*Figure 2*).

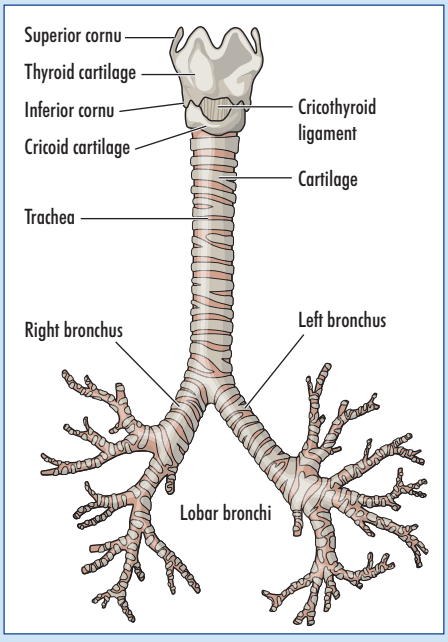

Figure 1. Wheeze-like sound may result from the passage of through localized or diffuse airway narrowing or obstruction from the level of the larynx to the small bronchi (Gray, 1918; Gong, 1990).

History

Wheeze may be a symptom if a patient reports it, or a sign if a physician detects it on clinical examination. When a patient complains of wheeze it is helpful to elicit a full description of the symptom including when, where, and for how long it is experienced, whether it is episodic, any exacerbating or relieving factors, and associated symptoms. The presence or absence of respiratory symptoms such as breathlessness, chest pain or tightness, cough, and sputum and systemic features such as presence of night sweats, fever and weight loss should be established.

Evidence of recent respiratory tract infection is significant since viral and bacterial respiratory infections can cause airway inflammation and airway hyperresponsiveness in healthy subjects and patients with chronic obstructive pulmonary disease or asthma. History of previous neck or thyroid surgery or intubation should be covered. Occupational and smoking histories are important and it is helpful to know if there is a personal or family history of atopy.

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Examination

Inspection

From the end of the bed there may be auditory and visual clues that a patient has airflow limitation. If airflow limitation is severe the patient may be pursed lip breathing and using accessory muscles to help his/her ventilation. Wheeze from the patient may be audible without the aid of the stethoscope, or the patient may be cachectic suggesting lung carcinoma or very advanced chronic obstructive pulmonary disease. There may be inhalers at the beside which suggest chronic obstructive pulmonary disease or asthma. There may be a sputum pot containing mucky sputum which suggests bronchiectasis. Observe the chest wall and note whether intercostal recession is present, if the chest wall is symmetrical and if any scars are present.

Palpation

It should be checked that the trachea is central and chest expansion should be noted. A patient with airflow limitation as a result of chronic obstructive pulmonary disease for example may have a hyperexpanded chest and symmetrically reduced chest expansion.

Percussion

The percussion note may be hyperresonant when the chest is hyperexpanded, all lobes should be percussed.

Auscultation

The diaphragm is conventionally used for auscultation of lung sounds which should be listened for over all lung lobes (*Figure 3*). The difference between the bell and the diaphragm with respect to their effect on sound transmission depends on the stethoscope used. Lower frequency sounds (37.5–112.5 Hz) are better amplified by the bell than the diaphragm and higher frequency sounds are generally less attenuated by the diaphragm than the bell (Abella et al, 1992).

Wheeze tends to be a high frequency sound so is theoretically best heard with the diaphragm. It may be present in expiration, inspiration or both, and should be carefully differentiated from stridor and rhonchus. Stridor indicates an upper airway obstruction and may be heard over the upper airways or at a distance without a stethoscope. Rhonchus is a lower pitched sound that is associated with secretions in larger airways and often clears with coughing.

Typically wheeze in asthma and chronic obstructive pulmonary disease is generalized and polyphonic (composed of several different pitch sounds) whereas wheeze

Figure 2. Postulated mechanism of wheeze. a. The stability of the airway wall depends upon a balance between internal air pressure and external forces and on the mechanical characteristics of the airway itself. b. When a narrowing of the lumen occurs, the air velocity must increase through the constricted region to maintain a constant mass flow rate. According to Benoulli's principle, this leads to a decrease in air pressure in the constricted region, thus allowing external compressive forces to further collapse the airway. c. When the lumen has been reduced so much that the flow rate decreases, the process reverses as the pressure inside the airway begins to increase and reopen the lumen. d. When conditions are right, the airway wall 'flutters' between open and nearly closed states and produces a continuous sound whose amplitude, pitch, and duration depend on the airflow and mechanical parameters involved (Murphy and Loudon, 1999).

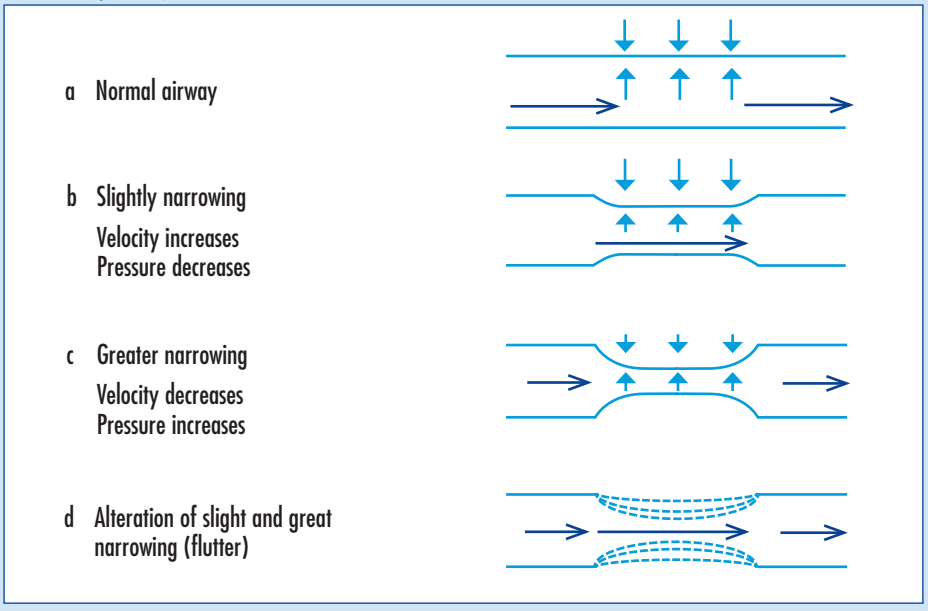
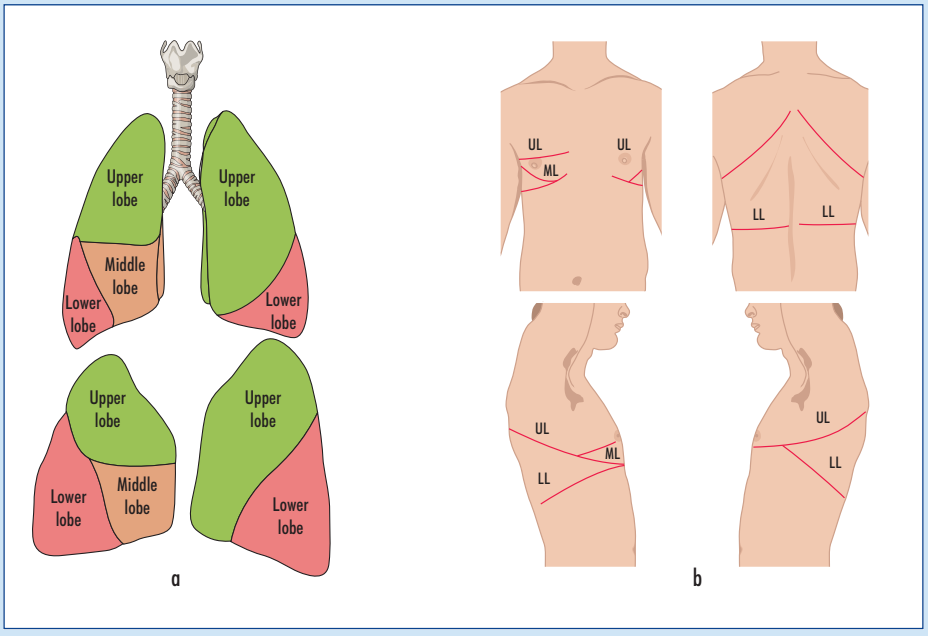


Figure 3. a. Lobes of the lung. b. Diagram indicating where to auscultate to check different lobes. All lobes should be auscultated. Comparison between sides helps to differentiate normal from abnormal lung sounds for unilateral pathology. LL = lower lobe; ML = middle lobe; UL = upper lobe.



resulting from localized pathology is localized and monophonic (single pitch sound). While the findings are not pathognomonic, it is important to consider whether an obstructive structural lesion could be present in patients with localized monophonic wheeze to avoid missing the diagnosis. It is also very important for accurate diagnosis to carefully distinguish stridor from wheeze (Ravenna et al, 2002; Bohadana et al, 2014).

Putting it all together

What you might say in your PACES examination for a patient with chronic obstructive pulmonary disease:

'On examination of this 57-year-old Caucasian gentleman I note that he appears breathless at rest with a prolonged expiratory phase, a barrel-shaped chest, and the presence of tar staining of his right index and middle fingers. His percussion note is hyperresonant and on auscultation he has a widespread polyphonic expiratory wheeze. The likely diagnosis is chronic obstructive pulmonary disease and my differential diagnosis would include asthma and bronchiectasis.'

Reliability of sign

Do physicians agree on the presence of wheeze? Inter-rater agreement is conventionally measured with Cohen's κ where if the raters are in complete agreement the κ is one and if they agree no more than would be expected by chance the κ is zero. Inter-rater agreement on the presence of wheeze on auscultation ranges from moderate (κ 0.43) to almost perfect (κ 0.93) (Joshua et al, 2005).

Airflow limitation can be variable as a consequence of the disease process itself or in response to treatment and wheeze may be absent altogether in severe disease when airflow is insufficient to generate an audible sound. This may help to explain the poor inter-rater agreement seen for wheeze but poor inter-rater agreement is also seen for other components of the respiratory examination such as dullness to percussion (κ 0.52) (Joshua et al, 2005).

Table 1 listed the sensitivity, specificity and likelihood ratios of selected clinical signs for detecting airflow limitation. Note that wheezing has a poor sensitivity (a high false negative rate) but a very high specificity, indicating that the presence of wheeze on auscultation almost always denotes airflow limitation (Holleman and Simel, 1995). These studies used spirometric reference standards for airflow limitation and the authors point out that disease with variable airflow limitation, such as asthma, may be overlooked if examined between attacks (Holleman and Simel, 1995).

Causes of wheeze

Causes of wheeze can be grouped according to the anatomical level of obstruction as either extrathoracic, intrathoracic central airway (trachea and bronchus), and intrathoracic lower airway (*Table 2*). Obstruction may arise as a result of external compression from outside the lumen (extraluminal), e.g. by a thoracic goitre, from the wall of the lumen (intramural), e.g. bronchial carcinoma, or from inside the lumen (intraluminal), e.g. foreign body aspiration.

Investigation and management of wheeze

Investigations can be divided into simple bedside tests, blood tests, imaging and special tests. Investigation choice depends on the differential diagnoses under consideration and is modified by earlier tests. For example, an abnormal chest radiograph or flow volume loop might raise the suspicion of a mass lesion and prompt a computed tomography scan or bronchoscopy. Management depends on the underlying diagnosis unless the patient is acutely compromised in which case a standard ABC resuscitation approach is followed.

Simple tests for the patient with wheeze include pulse oximetry, peak expiratory flow rate, and spirometry with reversibility testing. Asthma is diagnosed on the basis of a clinical assessment and a measure of airflow limitation, spirometry (forced expiratory volume in 1 second/forced vital capacity < 0.7) is the preferred initial test with peak expiratory flow rate reserved for if spirometry is unavailable (British Thoracic Society, 2011). Diagnosis of chronic obstructive pulmonary disease requires confirmation of airflow obstruction by performing post-bronchodilator spirometry (forced expiratory volume in 1 second/forced vital capacity < 0.7) and to grade severity on the basis of the forced expiratory volume in 1 second % predicted in order to guide treatment (National Institute for Health and Clinical Excellence, 2010).

Blood tests include full blood count, urea and electrolytes, brain natriuretic peptide, calcium, blood cultures and inflammatory markers to investigate the possibility of infective exacerbation of an underlying respiratory disease causing wheeze, heart failure and malignancy.

A chest radiograph is routinely obtained and a high resolution computed tomography is helpful if bronchiectasis or neoplasm are being actively considered. Bronchoscopy is particularly helpful when a foreign body or malignancy is suspected. Provocation testing is indicated for selected patients who are suspected of having asthma when there is diagnostic uncertainty on the basis of the history, pulmonary function tests, and response to treatment (Irvin, 2014).

Conclusions

Wheeze is a common and important clinical sign which is strongly suggestive of airflow limitation. Inter-rater agreement for the detection of wheeze is fair and the presence of wheeze rules in airflow limitation (specificity 99.6%) but its absence does not rule it out (sensitivity 15%). BJHM

Table 1. Sensitivity, specificity, and likelihood ratios of selected clinical signs for detecting airflow limitation

Clinical sign	Sensitivity	Specificity	Likelihood ratio+	Likelihood ratio-
Wheezing	15	99.6	36	0.85
Barrel chest	10	99	10	0.9
Hyperresonance	32	94	4.8	0.73
Decreased breath sound	37	90	3.7	0.7
Accessory muscle use	24	100	*	0.7

* This item was studied in too few subjects to yield meaningful results. From Holleman and Simel (1995)

Conflict of interest: none.

Abella M, Formolo J, Penney DG (1992) Comparison of the acoustic properties of six popular stethoscopes. *Eng J Acoust Soc Am* **91**(4 Pt 1): 2224–8

Bohadana A, Izbicki G, Kraman SS (2014) Fundamentals of Lung Auscultation. *N Engl J Med* **370**(8): 744–51

British Thoracic Society (2011) British guideline on the management of asthma quick reference guide. www.brit-thoracic.org.uk/document-library/clinical-information/asthma/btssign-asthma-guideline-quick-reference-guide/ (accessed 1 July 2014)

Gavriely N, Shee TR, Cugell DW et al (1989) Flutter in flow-limited collapsible tubes: a mechanism for generation of wheezes. *J Appl Physiol* **66**(5): 2251–61

Gray H (1918) Anatomy of the Human Body. *Ann Surg* **68**(5): 564–6

Gong H Jr (1990) Wheezing and asthma. In: Walker HK, Hall WD, Hurst JW, eds. *Clinical methods.* Butterworths, Boston

Holleman DR, Simel DL (1995) Does the clinical examination predict airflow limitation? *JAMA* **273**(4): 313–19

Hopkin J (2012) The clinical presentation of respiratory disease. In: Warrell DA, Cox TM, Firth JD, eds. *Oxford Textbook of Medicine.* 5th edn. Oxford University Press, New York

Irvin CG (2014) Bronchoprovocation testing. www.uptodate.com/contents/bronchoprovocation-testing (accessed 1 July 2014)

Irwin RS (2014) Evaluation of wheezing illnesses other than asthma in adults. www.uptodate.com/contents/evaluation-of-wheezing-illnesses-other-than-asthma-in-adults (accessed 1 July 2014)

Joshua AM, Celermajer DS, Stockler MR (2005) Beauty is in the eye of the examiner: reaching agreement about physical signs and their value. *Intern Med J* **35**(3): 178–87

Loudon R, Murphy RLH Jr (1984) Lung sounds. *Am Rev Respir Dis* **130**: 663–73

Mikami R, Murao M, Cugell DW et al (1987) International Symposium on Lung Sounds. Synopsis of proceedings. *Chest* **92**(2): 342–5

Murphy RLH Jr, Loudon RG (1999) Lung Sound in Health and Disease. In: Seward EA, Davies GS, Marcy TW, eds. *Medical Management of Pulmonary Diseases.* CRC Press, USA: 111–21

National Institute for Health and Clinical Excellence (2010) Chronic obstructive pulmonary disease. Management of chronic obstructive pulmonary disease in adults in primary and secondary care. www.nice.org.uk/guidance/cg101/resources/guidance-chronic-obstructive-pulmonary-disease-pdf (accessed 1 July 2014)

Pasterkamp H, Kraman SS, Wodicka GR (1997) Respiratory sounds: advances beyond the stethoscope. *Am J Respir Crit Care Med* **156**(3): 974–87

Ravenna F, Caramori G, Panella GL et al (2002) An unusual case of congenital short trachea with very long bronchi mimicking bronchial asthma. *Thorax* **57**(4): 372–3

Strachan DP, Butland BK, Anderson HR (1996) Incidence and prognosis of asthma and wheezing illness from early childhood to age 33 in a national British cohort. *BMJ* **312**: 1195–9

KEY POINTS

- Wheeze is a musical, continuous, whistling-like abnormal breath sound that is usually heard in expiration, and suggests the presence of airflow limitation.
- It is important to consider whether wheeze is polyphonic and widespread, as in the obstructive lung diseases, or monophonic and localized, which suggests a fixed localized pathology such as bronchial carcinoma.
- In the PACES examination wheeze is most likely to be encountered in patients with obstructive lung diseases such as chronic obstructive pulmonary disease, asthma or bronchiectasis.

Table 2. Common and important causes of wheeze. Common causes in the PACES exam are shown in bold

Cause		Examination features to look for	Investigations
Extrathoracic	Anaphylaxis	Acute respiratory compromise, wheeze, stridor, rash, facial swelling and hypotension	Serum or plasma total tryptase or plasma histamine
	Vocal cord dysfunction	Inspiratory stridor, dysphonia	Laryngoscopy
	Vocal cord paralysis	Hoarse voice	Laryngoscopy
	Laryngeal stenosis	Dyspnea and wheeze or stridor	Flow, volume, loop and laryngoscopy
	Goitre	Dyspnea and wheeze or stridor, thyroid mass	Thyroid-stimulating hormone, neck and/or chest radiograph, computed tomography
Intrathoracic central airway	Lung cancer	Cachexia, tar staining, localized monophonic wheeze	High resolution computed tomography, bronchoscopy
	Tracheal stenosis	Dyspnoea and wheeze or stridor, tracheostomy scar	Computed tomography, bronchoscopy
	Compression from mediastinal mass or lymphadenopathy	Dyspnoea and wheeze or stridor	Computed tomography, biopsy
Intrathoracic lower airway	**Asthma**	Polyphonic wheeze, widespread, quality of which does not change on coughing. Inhaler close by	Spirometry, reversibility testing
	Chronic obstructive pulmonary disease	Hyperexpanded chest. Tar staining	Spirometry
	Bronchiectasis	Sputum pot at the bedside. Cough. Digital clubbing. Coarse crepitations the quality of which changes on coughing	High resolution computed tomography
	Pulmonary oedema	Extra heart sound (S3), raised jugular venous pulse, sacral and ankle oedema (if right-sided heart failure also present)	Electrocardiogram, chest X-ray, brain natriuretic peptide, echocardiogram

From Irwin (2014)