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IAP Clinical Cases in Pediatrics for Postgraduates







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CHAPTER 4

Respiratory System

- History Taking and Clinical Examination of Respiratory System
- Bronchiectasis
- Pleural Effusion
- Tuberculous Collapse Consolidation
- Spirometry

4.1 HISTORY TAKING AND CLINICAL EXAMINATION OF RESPIRATORY SYSTEM

Chandan Kumar KM

HISTORY TAKING

History taking is the most imperative part of clinical medicine. Like in any other system, the history of the present illness should be clear and chronologically narrated.

Chief Complaints

Presenting complaints include the major concern that prompted consultation (chief complaint) and a chronological description of the problem. Clarification of its onset, frequency, timing, duration and severity, relation to specific circumstances, and response to medication already used should be sought.

History of Present Illness

Cardinal Presenting Symptoms in Respiratory Evaluation

Running nose:

- The most common complaint in clinical practice, majority are acute viral infections, self-limiting
- In under 5 wheezers, this can be the forerunner for acute exacerbations
- Chronic running nose—onset in early infancy, primary ciliary dyskinesia
- Recurrent episodes—allergic rhinitis
- Recurrent sinopulmonary infection—primary immunodeficiency.

Cough:

- *Onset:*
  - Sudden onset—airway foreign body
  - If it follows a rhinitis <1 year—bronchiolitis.
  - If it persists for >4 weeks—chronic; chronic wet (moist) cough—suggestive of chronic suppurative lung disease/bronchiectasis.
  - If recurrent dry cough with symptom-free interval in between—asthma
  - If unremittant cough persisting for >2 weeks—tuberculosis (TB) to be considered among other causes.
- *Duration:* Less than 4 weeks acute, more than 4 weeks—chronic
- *Frequency:* Recurrent cough—if dry, under five wheeze/asthma, if wet (moist)—suppurative lung diseases
- *Timing:*
  - Nocturnal cough, if immediately on lying down—postnasal drip, if within an hour of lying down—gastroesophageal reflux disease (GERD), under five wheeze/asthma if middle of the night.
  - Productive cough with change in posture is most often seen in suppurative lung diseases.

Cough associated with chest pain: Pleuritis

- *Quality:*
  - Whooping cough—pertussis
  - Staccato cough—Mycoplasma infection

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- Barking/tracheal cough—tracheomalacia, acute laryngotracheo bronchitis
- Wet cough—suppurative lung disease

- *Wet (moist):*
  - Chronic wet cough—suppurative lung disease
  - *Quantity:* Small—asthma; moderate and large—bronchiectasis (spoon full or handful)
  - *Consistency:* Recent change —acute exacerbation
  - *Color of sputum:* White—asthma, yellow—denuded respiratory epithelial cells, and greenish—bacterial infection
  - *Blood in sputum:* Bronchiectasis, TB, and pulmonary hemosiderosis
- *Aggravating/relieving:* Aggravated by physical activity, crying, laughing, and cold weather—asthma/under five wheeze
- *Associated symptoms:*
  - Fever—infective etiology
  - Feeding—aspiration pneumonia and GERD
  - Diarrhea or steatorrhea—cystic fibrosis
  - Recurrent diarrhea—primary immunodeficiency
  - Failure to thrive—TB, bronchiectasis, and interstitial lung disease
  - Nasal polyps—cystic fibrosis, chronic sinusitis, and allergic rhinitis.

Halitosis: Chronic rhinosinusitis, tonsillitis, and suppurative lung disease.

Difficulty in breathing or dyspnea:

- *Onset:*
  - Since early infancy, congenital pulmonary airway malformations, surfactant protein deficiency, and chronic lung disease of prematurity
  - Hyperacute—airway foreign body, anaphylaxis, and hereditary angioneurotic edema
  - Acute—pneumonia, pleural effusion, and empyema
  - Chronic—interstitial lung disease and bronchiectasis
  - Recurrent—asthma
- *Aggravating:*
  - Dyspnea on exertion—exercise-induced asthma or interstitial lung diseases
  - Severity: Enquire about daily routine and level of physical activity.

Medical Research Council (MRC) scale breathlessness is given in **Table 1**.

Fast breathing:

- *Silent fast breathing:* Pulmonary—pneumonia, congenital lung malformation, pulmonary hypertension, and interstitial lung disease
- *Nonpulmonary:* Congenital heart disease with left to right shunt and metabolic acidosis.

Noisy breathing:

- It is important to accurately identify the type of noise, as majority of parent may generalize all added sounds as wheeze.

TABLE 1: Medical Research Council (MRC) scale breathlessness (can be used for older children and adolescents).

Grade breathlessness	*Description*
1	Only get breathless with strenuous exercise
2	Get out of breath when hurrying on the level or up a slight hill
3	Walk slower than people of the same age on the level because of breathlessness or have to stop for breath when walking at my own pace on the level
4	Stop for breath after walking 100 yards or after a few minutes on the level
5	Too breathless to leave the house

Source: Medical Research Council. (2021). Home. [online] Available from https://mrc.ukri.org/ [Last accessed May, 2021].

- Types—Wheeze, rattle, snore, stridor, and grunt
- *Onset:*
  - *Onset since early infancy:* Stridor—laryngomalacia
  - *Hyperacute onset:* Stridor/wheeze—anaphylaxis and airway foreign body
  - *Acute onset:* Wheeze—asthma, grunting—pneumonia, and stridor—laryngo-trachea-bronchitis
  - *Chronic onset:* Stridor—laryngomalacia, vascular ring, and subglottic stenosis
  - *Recurrent episodes:* Stridor—hereditary angioneurotic edema and wheeze—asthma
- *Aggravating:*
  - Food—anaphylaxis
  - Changes with position and activity—laryngomalacia
  - *Viral infections:* Wheeze—acute asthma.

Ear symptoms:

- Recurrent otitis media—primary immunodeficiency and primary ciliary dyskinesia
- Chronic suppurative otitis media (CSOM—Immunodeficiency)
- Recurrent middle ear effusion and conductive hearing loss—primary ciliary dyskinesia
- Hearing impairment on long-term antibiotic—aminoglycosides use in cystic fibrosis.

Chest pain:

- Most often is associated with musculoskeletal pain
- *Exertion/physical activity:* Asthma
- *Febrile child with pneumonia:* Pleural effusion, primary pulmonary hypertension

Bad child rearing practices: Lipoid pneumonia and recurrent respiratory infection.

History of Past Illness

- Measles, pertussis, TB—bronchiectasis
- Bronchiolitis in early infancy—under-five wheeze

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- Prolonged ventilation in newborn period with oxygen dependency—chronic lung disease of prematurity, congenital surfactant protein deficiency
- Extreme preterm and prolonged oxygen dependency—chronic lung disease of prematurity
- Prolonged ventilation and failed extubation—secondary airway malacia
- Cow's milk protein allergy or intolerance—atopy and asthma
- Trachea esophageal fistula (TEF) operated—aspiration, esophageal dysmotility, GERD
- Unusual or severe infection—primary immunodeficiency
- Adenovirus pneumonia—bronchiolitis obliterans
- Graft-versus-host disease (GVHD) following BMT—bronchiolitis obliterans organizing pneumonia (BOOP)
- Hemoptysis—TB, connective tissue disease

Antenatal History

- Oligohydramnios—pulmonary hypoplasia
- Polyhydramnios—TEF, congenital myopathy
- Decreased fetal movement—spinal muscular atrophy (SMA), congenital myopathy
- Diabetic mother—respiratory distress syndrome (RDS)
- *Antenatal USG:* Congenital pulmonary airway malformation, congenital diaphragmatic hernia, lung agenesis

Birth History

- Multiple doses of surfactant requirement—surfactant protein deficiency
- Preterm—chronic lung disease of prematurity, airway malacias
- Prolonged ventilation—secondary tracheomalacia
- Chorioamnionitis—congenital pneumonia
- Maternal CMV, Herpes—congenital pneumonia

Neonatal History

- Low birth weight and small for gestation baby—under five wheeze
- Delayed fall of umbilical cord—leukocyte adhesion defect
- Transient tachypnea of newborn (TTNB)—primary ciliary dyskinesia
- Hypoxic-ischemic encephalopathy (HIE) with bulbar involvement—swallowing dysfunction, aspiration pneumonia
- Failed extubation—SMA, congenital myopathy.

Developmental History

- Children with neurodisability, cerebral palsy, neuromuscular disease [SMA, Duchenne Muscular Dystrophy (DMD), etc.]—GERD, swallowing dysfunction, and aspiration pneumonia
- Severe obstructive sleep apnea (OSA)—Attention-deficit/hyperactivity disorder (ADHD).

Immunization History

- Attention should be paid regarding respiratory vaccines.
- Enquire about Bacille Calmette-Guérin (BCG), diphtheria, pertussis, measles, pneumococcal, influenza vaccination status.

Nutritional History

- Chronic pulmonary condition and nutrition—negatively influence each other
- Malnutrition—predispose infections
- Overweight and obesity—asthma, OSA syndrome
- Gastroesophageal reflux disease—poor asthma control
- Swallowing dysfunction and dysphagia, choking episodes, and aspiration of feeds—neurodisability, neuromuscular diseases
- *Obesity, overeating and behavior disorders:* OSA—Prader-Willi syndrome

Personal History

Atopic dermatitis, allergic rhinitis, urticaria or anaphylaxis and pets at home.

Sleep History

Important in respiratory system cases:

- Time to bed, time off from bed, quality of sleep and screen time
- History of snoring, frequency, loudness, any gasping episodes, open mouth breathing, restless sleep, feeling unrefreshed in morning, hyperactivity, inattention, bed wetting, poor schooling, falling grades, and headache

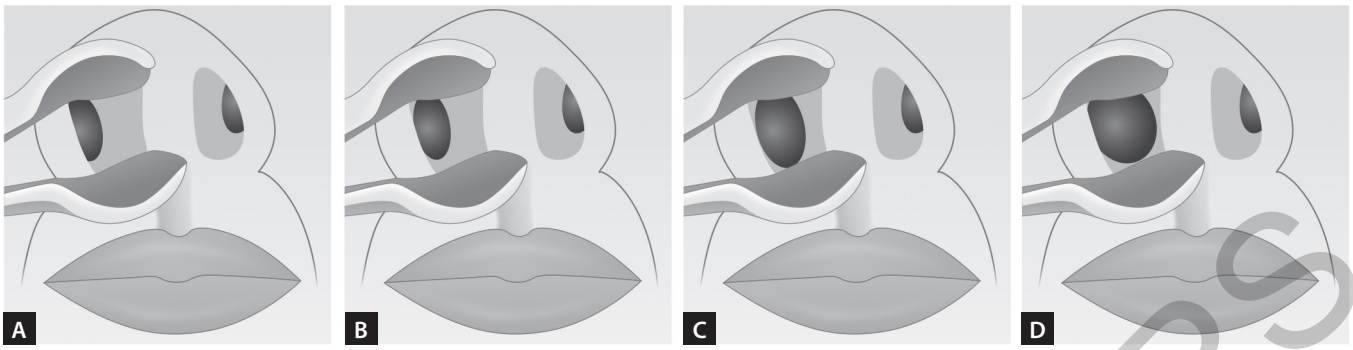
Family History

- Parental consanguinity—primary ciliary dyskinesia, cystic fibrosis, primary immunodeficiency
- Parental smoking—asthma trigger
- Parental asthma and atopy
- *Family dynamics:* Children with neurodisability, SMA and DMD—parents ability to cope with added emotional and physical needs, availability of extra help.

Social and Environmental History

- Type of housing and living conditions, home location, and toilet western or Indian
- Overcrowding—pneumonia, TB
- History of smoking in adolescents—poor asthma control
- Recurrent nasal symptoms on outdoor play—pollen allergy
- Wood burning, factories, smoke—asthma flare up or poor control.
- **Contact history:** History of recent contact with TB

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Figs. 1A to D: Grading of Inferior turbinate hypertrophy. (A) Grade 1 (0–25% of total airway space); (B) Grade 2 (26–50% of total airway space); (C) Grade 3 (51–75% of total airway space); (D) Grade 4 (76–100% of total airway space).

EXAMINATION OF RESPIRATORY SYSTEM

Examination of Upper Respiratory System

Examination of Ear

- Examined digitally, signs of infection
- Otoscope—examine the inner part of external auditory canal
- Recurrent ear infection with discharge—immunodeficiency.

Examination of Nose and Paranasal Sinuses

- Examine the nose digitally and document bilateral patency, color and size of the mucosa should be noted (inferior turbinate) **(Figs. 1 A to D)**.
- Occluding each side while feeling and listening for air flow through the other nostril
- Bluish coloration of the infraorbital region ("allergic shiners")—atopy
- Bilateral fold of skin below lower eyelid—Dennie–Morgan line can be seen in atopic dermatitis and allergic rhinitis.
- Transverse crease ("allergic salute") running at the junction of the cartilaginous and bony portion of the nose—allergic rhinitis
- Midfacial hypoplasia and OSA
- Nasal polyps arise—primary ciliary dyskinesia, cystic fibrosis, asthma
- Tenderness—frontal and maxillary paranasal sinuses: Sinusitis.

Examination of Throat

- The oropharynx should be inspected for its size and signs of malformation, such as cleft palate, and for signs of obstruction by enlarged tonsils.
- High-arched palate, overcrowding of teeth, adenoidal facies—OSA
- Cleft palate—aspiration pneumonia
- Post-cleft palate repair—OSA

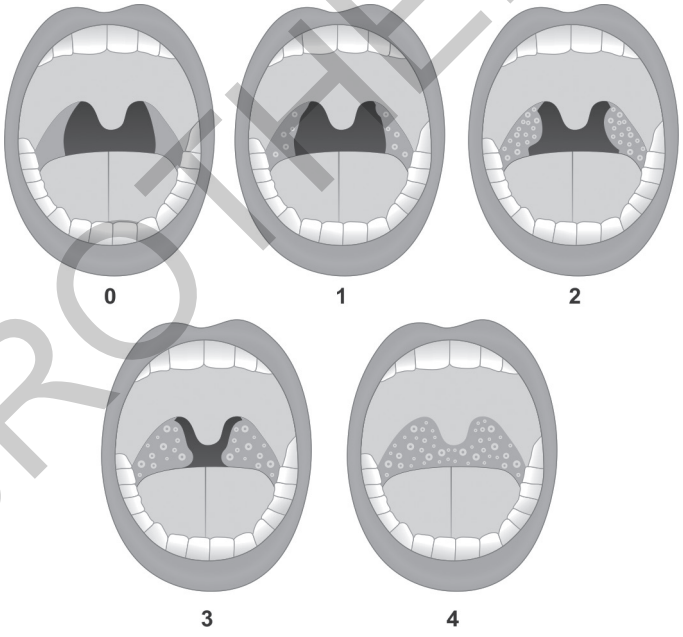


Fig. 2: *Brodsky grading scale:* Tonsils within the tonsillar fossa.
Tonsils within the tonsillar fossa—Grade 0; Tonsils just outside of the tonsillar fossa and occupy 25% of the oropharyngeal width—Grade 1; Tonsils occupy 26–50% of the oropharyngeal width—Grade 2; Tonsils occupy 51–75% of the oropharyngeal width—Grade 3; Tonsils occupy >75% of the oropharyngeal width—Grade 4

- *Dental caries and halitosis:* Chronic sinopulmonary infections
- Large tongue, retrognathia—OSA.

Tonsil size: Tonsillar hypertrophy grading is shown in **Figure 2**.

Examination of Lower Respiratory System

- Traditional sequence of physical examination (inspection, palpation, auscultation and percussion) may be varied depending on the circumstances, and in particularly in young children to gain more cooperation.
- Whenever clinical situation permits, examination should be conducted in standing position, as lying down and sitting positions may impair the appreciation of clinical findings.

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Inspection

- *Tracheal position* **(Table 2)**:
  - Normally trachea—center or to right
  - Change in tracheal position—mediastinal shift
  - Trail sign—prominence of clavicular head of the sternomastoid muscle to the side of tracheal deviation due to increased tension in pre-tracheal fascia enclosing the tendon
- *Apical impulse:* It is important to locate exact position of cardiac apex as it may be displaced in diseases of lung or pleura.
- *Shape of chest:*
  - Infancy and early childhood—circular, ribs are more horizontal and it decreases as the child grows and the ribs descend down.
  - An abnormal shape of chest can be symmetrical or asymmetrical.
  - *Harrison's sulci:* Indrawing of ribs form symmetrical horizontal groove above costal margin at diaphragm insertion resulting from increased work of breathing due to strong diaphragmatic contraction suggestive of possible lung disease from early infancy.
  - *Barrel-shaped chest:* Anteroposterior diameter increased than normal giving barrel shape to chest seen in air trapping due to poorly controlled asthma or in acute asthma attack.
  - *Pectus excavatum:* There is depression in the sternum involving whole length or partial. Significant depression can lead to restrictive lung problems.
  - *Pectus carinatum:* Localized prominence of sternum may be associated with Harrison's sulci in chronic respiratory diseases.
- *Respiratory rate:* Count the respiratory rate for 1 whole minute. Respiratory rate varies with the age and behavior of the child **(Table 3)**.
- *Rhythm:*
  - Normal respiration—regular in rhythm with inspiration longer than expiration
  - *Bradypnea*—abnormally slow rate of breathing—metabolic alkalosis/central nervous system depression
  - *Tachypnea*—abnormally rapid rate of breathing—various respiratory disorders
  - *Dyspnea*—difficulty in breathing
  - *Apnea*—cessation of breathing
  - *Hyperpnea*—abnormally deep respirations
  - *Periodic breathing*—respiratory pauses of <6 seconds occur in groups of three or more that are separated by <20 seconds in preterm babies.
  - *Cheyne-Stokes breathing*—cycles of increasing and decreasing tidal volumes separated by apnea (congestive heart failure and increased intracranial pressure)
  - *Biot's breathing*—irregular cycles of respiration at variable tidal volumes interrupted by apnea and severe brain damage
- *Paradoxical respiratory movements:*
  - In this condition, chest wall moves in during inspiration and moves out during expiration which is reverse of what happens normally during respiration. Mechanism—the more negative intrapleural pressure during inspiration against a high airway resistance leads to retraction of the pliable portions of the chest wall, including the intercostal and subcostal tissues and the supraclavicular and suprasternal fossae
  - Paralysis of intercostal muscles
- *Effort:*
  - Normal respiration—effortless
  - Look for signs of increased respiratory effort
  - Retractions easily visible in newborn infant—intercostal tissues are thinner and more compliant chest wall.
  - In general suprasternal, sternal and substernal retractions are observed in larger airway obstruction, subcostal retraction in smaller airway obstruction while intercostal retractions are more indicative of parenchymal and interstitial pathology
  - Contraction of sternocleidomastoid muscles and in-drawing of supraclavicular fossae—airway obstruction
  - Head bobbing, best observed when the child rests with the head supported slightly.
  - Flaring of the alae nasi—sensitive sign of respiratory distress
  - *Hoover's sign*—inspiratory indrawing of lateral rib cage—severe pneumonia and obstructive airway disease

TABLE 2: Tracheal position in respiratory conditions.

Normal position	*Shifted to side of pathology (pulled)*	*Shifted to opposite side of pathology (pushed)*
Bronchial asthma	Collapse	Pneumothorax, pleural effusion, empyema, hemothorax
Bronchopneumonia	Fibrosis/scarring	Mediastinal mass
Bilateral bronchiectasis	Traction bronchiectasis	Diaphragmatic hernia
Interstitial lung disease		

TABLE 3: Respiratory rate in different age groups.

Normal respiratory rate	*Breaths per minutes*
Preterm	34–70
Term 0–3 months	35–55
1–3 years	20–30
3–6 years	20–25
6–12 years	14–22

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- Paradoxical breathing also occurs during sleep—upper airway obstruction (UAO)
- Symmetry of respiratory chest excursions
- Unilateral diseases affecting lungs, pleura, chest wall or diaphragm—asymmetric breathing movements
- Trauma to rib cage cause fractures and "flail chest"—local paradoxical movement
- Pain during respiration—"splinting" with flexion of trunk toward affected side and decreased respiratory movements pleurisy and pleural effusion

- *Audible sounds* **(Table 4)**
- *Chest expansion:*
  - Observe the expansion of chest
  - Neuromuscular diseases—paradoxical breathing, poor respiratory effort
- *Spine:* Spinal deformities—significant decrease in thoracic size and limit the lung expansion—spine abnormality and neuromuscular disease
- *Scar, sinus and operative marks:*
  - Always look for BCG scar
  - Scars due to previous chest tube insertion or surgical scar give clue to underlying pathology.

Palpation

- Palpation follows chest inspection to confirm observations.
- Perform this procedure with warm hands
- Tracheal position

Technique:

- Tracheal position is assessed by placing the index and ring fingers on both sternal attachments of the sternocleidomastoid muscles. The trachea is then felt between these landmarks with the middle finger on the suprasternal notch.
- In small children, palpation is done with one index finger sliding gently inward over the suprasternal notch.

Movement of chest wall:

- *Apical area:* Place the palm of handover apical area from behind and look for degree of up and down movement.

TABLE 4: Added sounds.

Noise	*Site of origin*	*Causes*
Wheeze	Lower airway	Viral-induced wheeze and asthma
Rattle	Either or both intra-/extrathoracic airway	Acute viral bronchitis and chronic sputum retention
Stridor	Upper airway	Viral croup, laryngomalacia
Snore	Oro-nasopharyngeal airway	Acute tonsillitis and adenotonsillar hypertrophy
Snuffle/snort	Nasal passage/nasopharynx	Acute viral cold and allergic rhinitis
Grunt	Alveoli/parenchymal	Pneumonia and respiratory distress syndrome

- *Infraclavicular area:* Place the palm of hand over infraclavicular area and note the degree of to and fro movements as patient takes breath.
- *Mammary and infra-mammary area:* While facing the patient, the examiner uses both hands to encircle the chest while thumb meet in midline. As patient breathes, side-to-side movement is noted by amount of thumb separation.
- *Scapular and infrascapular area:* While standing behind, examiner places two hands symmetrically on either side with hands actively stretched and thumb meeting at mid line. Observe movement of thumb from midline during inspiration.

Tactile vocal fremitus/voice-generated vibrations:

- *Technique:*
  - Best felt with palms of both hands just below base of fingers placed over corresponding sites on right and left hemithorax
  - Proceed symmetrically from apices to base
  - The patient is asked to produce low-frequency vibrations of sufficient amplitude by saying "ninety-nine" in a loud voice.
  - Young infants—crying may produce the vibrations that are felt as tactile fremitus over the chest wall.
  - Decreased—accumulation of air or fluid in pleural space reduces transmission
  - Asymmetric transmission usually indicates unilateral intrathoracic abnormalities.
  - VF increased—Consolidation. VF decreased—collapse, pneumothorax, and pleural effusion.
- *Percussion:*
  - Percussion is used to set tissues into vibration with an impulsive force so that their mechanical and acoustic response can be studied.
  - Determine state of underlying tissue and define boundaries.
- *Technique* **(Fig. 3)***:*
  - *Direct and indirect methods:* It is advisable to avoid direct methods especially in young children as it can be painful and may lose cooperation of the child.
  - The fundamental resonance of the thorax depends on body size and is between 300 and 400 Hz for small children.

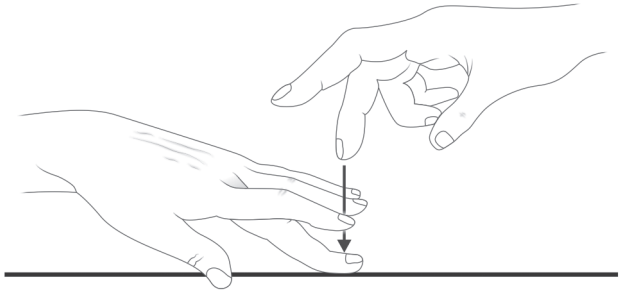


Fig. 3: Percussion technique.

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- Performed by light tapping with the tip of the middle finger (the plexor) on the middle phalanx of the other hand's middle finger (the pleximeter). The pleximeter should be placed firmly but not hard, and care should be taken that other fingers do not touch the chest wall, which may cause artificial dampening of the percussion note. Percussion should be gentle, with quick perpendicular movements of the plexor originating from the wrist.
- Symmetric sites over the anterior, lateral, and posterior surface of the chest should be compared in an orderly fashion and reported with reference to standard external anatomic landmarks.
- *Resonant:* Structures that absorb energy when struck by a sound at their natural frequency continue vibrating after the initial sound is gone.
- *Tympanic:* Vibrations are undamped and continue for a significant amount of time, and occurs when there is a large acoustic mismatch (e.g., tissue overlying an air-filled cavity).
- Dull note—rapid attenuation of the vibrations occurs when the underlying tissue is similar to the surface tissue and vibratory energy propagates away quickly.
- *Limitation:* Small pulmonary lesions < 2–3 cm, deep-seated pneumonia and pleural fluid of <100–200 mL may not be detected.
- Percussion notes in respiratory conditions are given in **Table 5**.

Auscultation

The auscultation of the respiratory system is an inexpensive, noninvasive, safe, easy-to-perform, and one of the oldest diagnostic techniques used by the physicians to diagnose various pulmonary diseases **(Fig. 4)**.

Physics of breath sounds: Three characters—(1) frequency, (2) intensity, and (3) timbre (quality of musical tone) differentiate two similar sounds.

Frequency and pitch:
- Number of sound waves or vibrations per second is frequency. Depends on wavelengths of sound.
- Pitch is subjective perception of sound's frequency.

Amplitude or loudness:
- Amplitude is related to energy of sound waves and is measured by height of sound waves.
- Loudness is the subjective perception of amplitude.

Quality or timber: Quality or timbre is an important property of sound that differentiates two sounds with same pitch and loudness.

Methods of performing auscultation:
- Done in a quiet room, preferably in a sitting/standing position.

TABLE 5: Different types of percussion note.

Type of tone	*Quality*	*Condition*
Resonant	Hollow	Normal
Hyper resonant	Booming	Pneumothorax
Dull	Thud like	Consolidation and collapse
Tympanic	Drum like	Stomach, intestine, and subcutaneous emphysema
Stony dull/flat	Compared to percussion over one's thigh, evoking extremely dull note with pain	Pleural effusion, empyema, and solid tumor

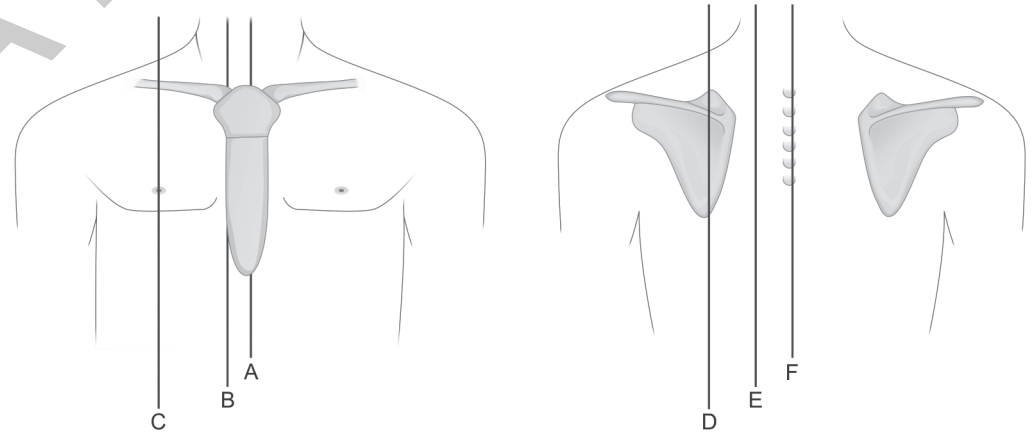


Fig. 4: Vertical reference lines. A: sternal; B: parasternal; C: midclavicular; D: scapular; E: paravertebral; F: spinous process.

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- If child cannot assume sitting posture, roll child from one side to other to examine back.
  - Always warm-up cold stethoscope by rubbing chest piece in your hands before placing it on naked body. Auscultation should never be done through the clothing.
  - Always compare symmetrical points on each side. Using diaphragm of stethoscope, start auscultation anteriorly at apices, and move downward till no breath sound is appreciated. Next, listen to back, starting at apices, and moving downward. At least one complete respiratory cycle should be heard at each site **(Fig. 5)**.
  - Listen for the quality of breath sounds, intensity of breath sounds, and presence of adventitious sounds.

Mechanism of breath sound production:

- Prerequisite for normal breath sound production is air flow along trachea-bronchial tree; however, not all types of airflow produce breath sound. Only turbulent airflow is responsible for breath sound production.
- Laminar flow occurs in low flow situations and is silent.
- Turbulency produces noise as air molecules collide with each other and with airway wall.
- Respiratory sounds heard in chest wall undergo attenuation by lungs and chest wall act as filter, not allowing high-frequency sounds, Therefore, sound heard over chest wall consists mainly of low frequencies.
- Lung sounds are generated within lungs, unlike transmitted voice sounds, which are generated by larynx.
- Compare the relative duration of inspiration and expiration in auscultation **(Fig. 6)**.

Normal breath sounds:

- Heard over the chest wall or trachea
- Basically, breath sounds contain background noises, on which adventitious sounds are sometimes superimposed
- Breath sounds are classified into normal tracheal sound, normal lung sound or vesicular breath sounds, and bronchial breath sound.

Normal lung or vesicular breath sounds ***(Fig. 7)****:*

- Vesicular breath sound is a misnomer as vesicles means alveoli, and this gives impression that breath sound is originating at alveolar level. Breath sounds cannot be generated at alveolar level since airflow is laminar within alveoli.
- Short expiratory phase is due to passive nature of expiration resulting in generation of less turbulent airflow.
- The inspiratory component originates in lobar and segmental airways, whereas expiratory component arises from more central airways.

Characteristics:

- Soft, low pitched, and rustling in quality
- Inspiratory phase lasts longer than the expiratory phase with an inspiratory-expiratory ratio (I:E) of about 2:1 during tidal breathing
- Intensity of inspiration is greater than that of expiration
- Inspiration is higher pitch than expiration
- No pause between inspiration and expiration

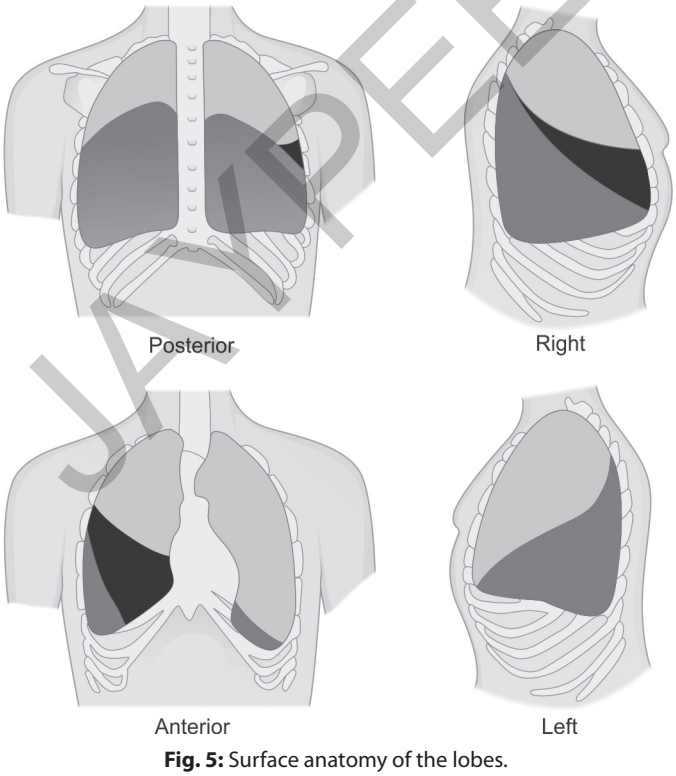


Fig. 5: Surface anatomy of the lobes.

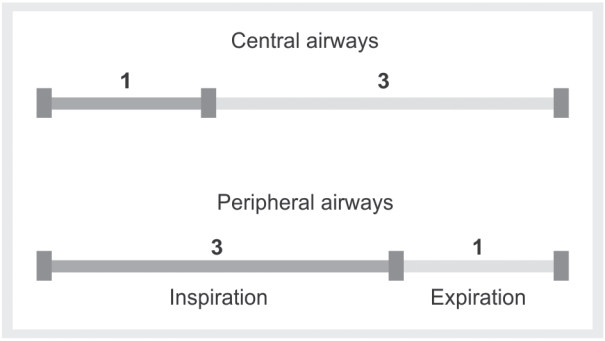


Fig. 6: I:E ratio during auscultation.



Fig. 7: Vesicular breath sound.

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- *Intensity can be reduced:* Weak sound generation and/or impaired transmission. Shallow breathing, airway obstruction, bulla, hyperinflation, pneumothorax, pleural effusion or thickening, and obesity
- Normal vesicular breath sound with prolonged expiration—obstructive airway diseases such as asthma and under five wheeze.

Normal Tracheal Breath sounds:

- Harsh, very loud, and high-pitched sound heard over trachea. Typical frequency of tracheal breath sound varies from 100 to 1,500 Hz; tracheal breath sound has both phases of respiratory cycle equal with distinct gap between them.
- Hollow tubular quality so it is a good model for studying bronchial breath sound. Tracheal breath sound helpful in detecting UAO.

Bronchial breath sound: Normally, heard anteriorly over manubrium and posteriorly between the C7 and T3 vertebrae **(Fig. 8)**.

Characteristics:

- It is loud, hollow, and high pitch.
- Expiratory phase longer than inspiratory phase with the I:E changing from normal 2:1 to 1:2
- There is distinct pause between inspiration and expiration due to absent alveolar phase
- It may be associated with whispering pectoriloquy.
- Bronchial breath sounds—subdivided into tubular, cavernous, and amphoric breath sound.



Fig. 8: Bronchial breath sound.

Tubular breath sound:

- High pitch, bronchial breath sound
- *Seen in the following conditions:*
  - Consolidation
  - Above level of pleural effusion
  - Pulmonary fibrosis
  - Atelectasis, if collapse segment is in contact with chest wall and bronchus is patent.
  - Mediastinal tumor over large patent bronchus.

Amphoric breath sounds:

- It is low pitch bronchial breath sound with high-pitch overtones, has a metallic character.
- Superficial large cavity (not <5–6 cm in diameter) with patent bronchi and open pneumothorax.
- Presence of amphoric breathing means alveolar destruction.

Cavernous breath sound: Low pitch bronchial breath sound heard over superficial large cavity with patent bronchus, abscess and bronchiectatic cavity with patent bronchi.

Respiratory sounds **(Table 6)**

Crackles with respect to the respiratory cycle are described in **Table 7 and Figure 9**.

Vocal resonance or vocal sounds: Produced by the larynx.

Mechanism:

- Produced when puffs of air pass through vocal folds, producing its vibration, unlike breath sounds and adventitious sounds, they are not produced in lungs. Voice sounds are subsequently modulated by filter function of supralaryngeal airway.
- Normally, in healthy person, due to filtering effect of air-filled lungs, voice sounds are unintelligible as higher frequencies are lost.
- When air in lungs is replaced by fluid or solid substances or lungs undergo atelectasis, voice sounds are better transmitted and become well-distinct.
- *There are three types:* (1) whispered pectoriloquy, (2) bronchophony, and (3) egophony.

TABLE 6: Mechanism of breath sound.

	Mechanisms	***Origin***	***Acoustics***	***Relevance***
Basic sounds				
Lung	Turbulent flow	Lobar to segmental airway	Low pass filter noises (<100 to >1,000 Hz)	• Regional ventilation • Airway caliber
Trachea	Turbulent flow	Trachea, larynx, and pharynx	Noise with resonance (<100 to >3,000 Hz)	Upper airway configuration
Adventitious sounds				
Wheeze	Airway wall flutter	Central and lower airway	Sinusoidal <100 to >1,000 Hz	• Airway obstruction • Flow limitation
Crackles	Airway wall stress relaxation	Central and lower airway	Rapidly dampened wave deflection	Airway closure, secretions

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TABLE 7: Differential diagnosis of crackles.

Early inspiratory[1]	***Mid to late—inspiratory***[2,3]
Atelectasis	Bronchiectasis
Bronchitis	Interstitial lung disease
Emphysema	Pulmonary edema
	Sarcoidosis

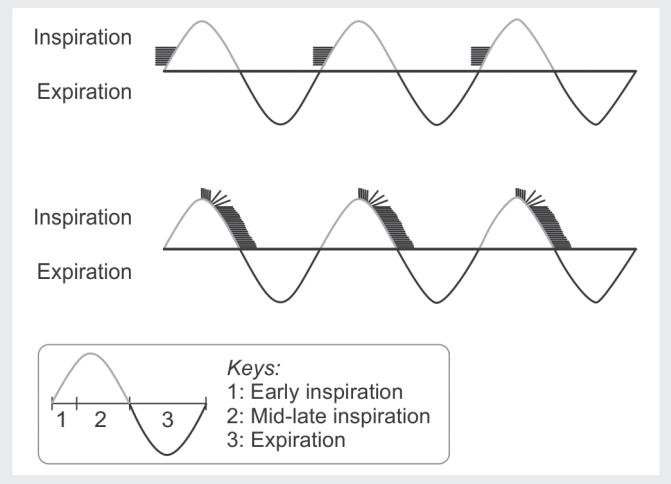


Fig. 9: Crackles in the inspiratory phase.

Bronchophony:
- *Technique:* Ask patient to recite word *"ninety-nine"* in a normal voice and listen to chest via stethoscope to each lung field.
- Present if sounds can be heard with an increase in intensity and clarity in consolidation.

Whispered pectoriloquy:
- During whispering, vocal folds do not vibrate, but are held close together. This produces a turbulent flow of air resulting in a windy sound characteristic of whispering.
- *Technique:* Ask patient to whisper a word such as "one-two-three" or "ninety-nine" and listen with a stethoscope.
- Normally, words are heard faintly.
- In consolidation, whispered sounds will be heard clearly and distinctly.

Egophony:
Technique: Ask the patient to say the word "Ee" and it will be transformed into "A." It is present in cases of consolidation or pleural effusion just above the area of dullness. Consolidated lungs cannot transmit the higher frequency of Ee, but can transmit the lower frequency of 'A' well, so 'Ee' becomes 'A.'

Adventitious lung sounds:
- Wheezes
- Crackles
- Squeak
- Stridor
- Pleural rub

Wheezes:
- Adventitious sounds are additional respiratory sounds superimposed on normal breath sounds.
- Wheezes are high-pitched continuous sounds, usually louder than underlying breath sounds and are often audible at patient's open mouth or by auscultation over trachea and occasionally at some distance from patient is expiratory in nature.
- Asthma and under five wheeze patients develop generalized airway obstruction; therefore, wheezes are heard all over the chest.
- Localized airway obstruction by a foreign body, mucous plug, or tumor produces focal wheezing.

Crackles:
- Crackles are discontinuous, explosive, and nonmusical adventitious lung sounds normally heard in inspiration.
- Classified as fine and coarse crackles based on their duration, loudness, pitch, timing in the respiratory cycle and relationship to coughing and changing body position.
- Fine crackles are produced within the small airways, medium crackles are caused by air bubbling through mucus in small bronchi, and coarse crackles arise from the large bronchi or the bronchiectatic segments.

Mechanisms of the production of crackles: Small airways that were collapsed during expiration snap open during inspiration as a gradient of gas pressure is developed across the collapsed airways. Sudden explosive opening of the collapsed airways induces a rapid equalization of gas pressures resulting in oscillations of the gas column and development of crackles. Also passage of air through the accumulated secretions within the large and medium-size airways, creating the bubbling sounds may contribute.

Stridor:
- Stridor is a loud, high-pitched, and musical sound produced by upper respiratory tract obstruction.
- Stridor is caused by the turbulent flow passing through a narrowed segment of the upper respiratory tract.
- It is louder over the neck than chest wall, mainly inspiratory.
- It indicates extrathoracic upper-airway obstruction (supraglottic lesions such as laryngomalacia and vocal cord lesion) when heard on inspiration.
- *Biphasic stridor:* It occurs in expiration if associated with intrathoracic tracheobronchial lesions (tracheomalacia, bronchomalacia, and extrinsic compression).
- It occurs in both phases if lesion is fixed, for example, subglottic stenosis.

Pleural rub:
- It is a nonmusical, short explosive sounds, grating, rubbing, creaky, or leathery in character and present in both phases of respiration.

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- Typically, the expiratory component mirrors the inspiratory component.
- It occurs due to inflamed pleural surface rubbing each other during breathing. Clinically, it is important to differentiate it from crackles.

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4.2 BRONCHIECTASIS

Kalpana S, Sarath Balaji B, Elilarasi S

BRIEF CASE REPORT

- A 7-year-old, female child brought with
- Complaint of cough—6 months
  - Cough—productive, more on awakening in the morning, daily, not associated with chest pain
- History of sputum—about 10 mL daily, on and off for the past 6 months purulent, occasional blood streaks
- History of fever—every month lasting 3 days, associated with increased sputum production, requiring antibiotics
- History of breathlessness—2 weeks
- History of contact with tuberculosis (TB)+

Spectrum of Cases

- Chronic cough with hemoptysis
- Pneumonia with underlying bronchiectasis (BT)
- Collapse consolidation with atelectatic BT

Complaints

- Onset of illness—several months to years
- Chronic wet (productive) cough—aggravated on waking up
- Sputum—large quantity/every time child coughs, mucopurulent, foul smelling +/– admixed with blood
- History of hemoptysis—small/large quantity
- Breathlessness
- Fever—active infection
- Features suggestive of acute exacerbation—change in sputum color and increase in quantity, increased cough, dyspnea, malaise, and fatigue

Past History

- History of recurrent aspiration/vomiting—gastro-esophageal reflux disease (GERD), achalasia, tracheoesophageal fistula
- History of foreign body aspiration
- History of recurrent respiratory infection
- History of any procedure under anesthesia
- History of near drowning
- History of dental extraction
- History of moist cough lasting 4 weeks or more and recurrent episodes (recurrent protracted bacterial bronchitis)
- History of measles and pertussis
- History of TB and antituberculous treatment (ATT)
- History suggestive of cystic fibrosis (CF)—recurrent respiratory tract infection (RRTI), passing bulky, oily, foul smelling stools, and symptoms of vitamin deficiency—night blindness, wrist and knee deformities, and skin bleeds
- History suggestive of immunodeficiency—RRTI/pneumonia, recurrent diarrhea, ear discharge, and abscess
- History suggestive of ataxia telangiectasia—history of recurrent infection, abnormality in walking, red eyes, and clumsiness in activity
- History suggestive of primary ciliary dyskinesia (PCD)—recurrent sinusitis, purulent rhinorrhea, and ear discharge

Development History

Preterm, cleft palate, oropharyngeal incoordination causing recurrent aspiration and subsequent BT

Immunization History

Pertussis, measles, pneumococcal, and flu vaccines.

CONTACT WITH TUBERCULOSIS

General Examination

- *Nutritional status*: Chronic malnutrition and failure to thrive
- Anemia
- Pan-digital clubbing

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Head-to-foot Examination

- Halitosis—symptoms of anaerobic infection in BT
- Sinus tenderness (older children)—chronic sinusitis in PCD
- Abscesses, scars of old abscess, and ear discharge—immunodeficiency
- Eyes—telangiectasia in ataxia telangiectasia
- Corrected cleft palate
- Retrognathia—Pierre Robin sequence
- Absent patella, yellow nails—syndromic causes of BT
- Petechiae, purpura, features of rickets (widening of wrist, double malleoli, Harrison's sulcus, beading of chest) corneal, and conjunctival xerosis—signs of vitamin deficiency due to malabsorption in CF
- External markers of TB
- Raised jugular venous pressure (JVP)—signs of cor pulmonale

RS Examination

- Tracheal position and apical impulse position (normal position or in the right side)
- Wasting of muscles
- Suprasternal supraclavicular and intercostal recession
- Harrison sulcus
- Drooping of shoulder
- Kyphoscoliosis
- Bronchial breath sound, if there is infection in any cavities.
- Coarse leathery crackles in affected areas

Other Systems

Situs inversus in Kartagener syndrome, developmental delay—oropharyngeal incoordination causing recurrent aspiration and subsequent BT.

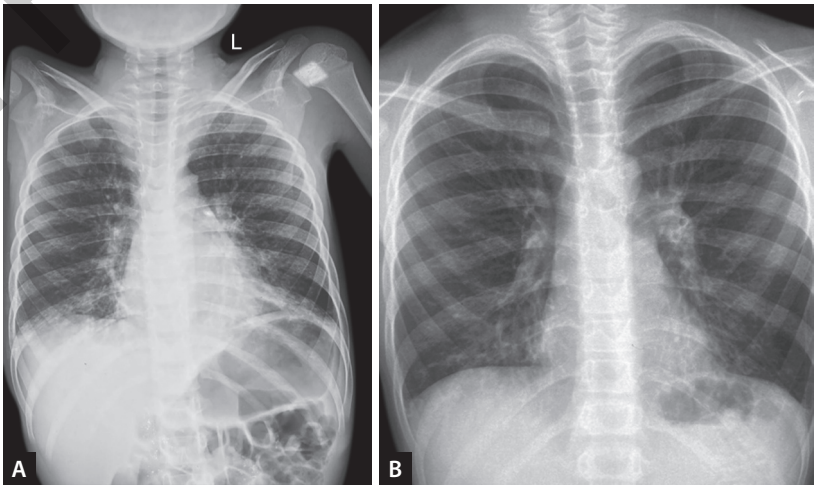
Summing Up History and Examination

Chronic wet cough for prolonged duration with production of purulent sputum, increases in morning, aggravated with change in posture, O/E undernourished, pallor, clubbing grade, with bilateral coarse, and leathery rales on auscultation with/without features of acute exacerbation (one needs to add the probable etiology or possible etiologies).

Laboratory Investigations

Confirm BT by imaging, investigations to find etiology and supportive investigations to find out the current infection and assess lung function serially.

- *Current investigation for exacerbation of infection*:
  - Complete blood count: Hemoglobin, leukocytosis—current infection
  - Sputum—potassium hydroxide (KOH) mount, Gram stain, bacterial and fungal culture sensitivity and aspergillus specific immunoglobulin E (IgE)
  - TB screening—Mantoux, cartridge-based nucleic acid amplification test (CBNAAT), *Mycobacterium* growth inhibitor tube (MGIT)
- *Confirm diagnosis:*
  - *Chest X-ray* ***(Fig. 1A and B)***:
    - Tramlines (thickened bronchial walls)
    - Tubular shadows (dilated and fluid filled bronchi)
    - Ring or cystic shadows (extreme bronchial dilatation)
    - Slight or severe volume loss—present—fibrosis/shrinkage of affected lung
    - Honey comb appearance (multiple cystic lesions) in advanced BT
    - Crowding of bronchi due to loss of lung volume
    - Dextrocardia/situs inversus totalis
    - Hyperinflation due to air trapping in CF
    - Cardiomegaly with filling up of pulmonary bay—s/o pulmonary hypertension (HT)



Figs. 1A and B: Bronchiectasis changes with pneumonia both lower zones.
Source: Personal collection. Dr Sarath Balaji, Pediatric Pulmonologist, Institute of Child Health and Hospital for Children, Madras Medical College, Chennai, Tamil Nadu, India.

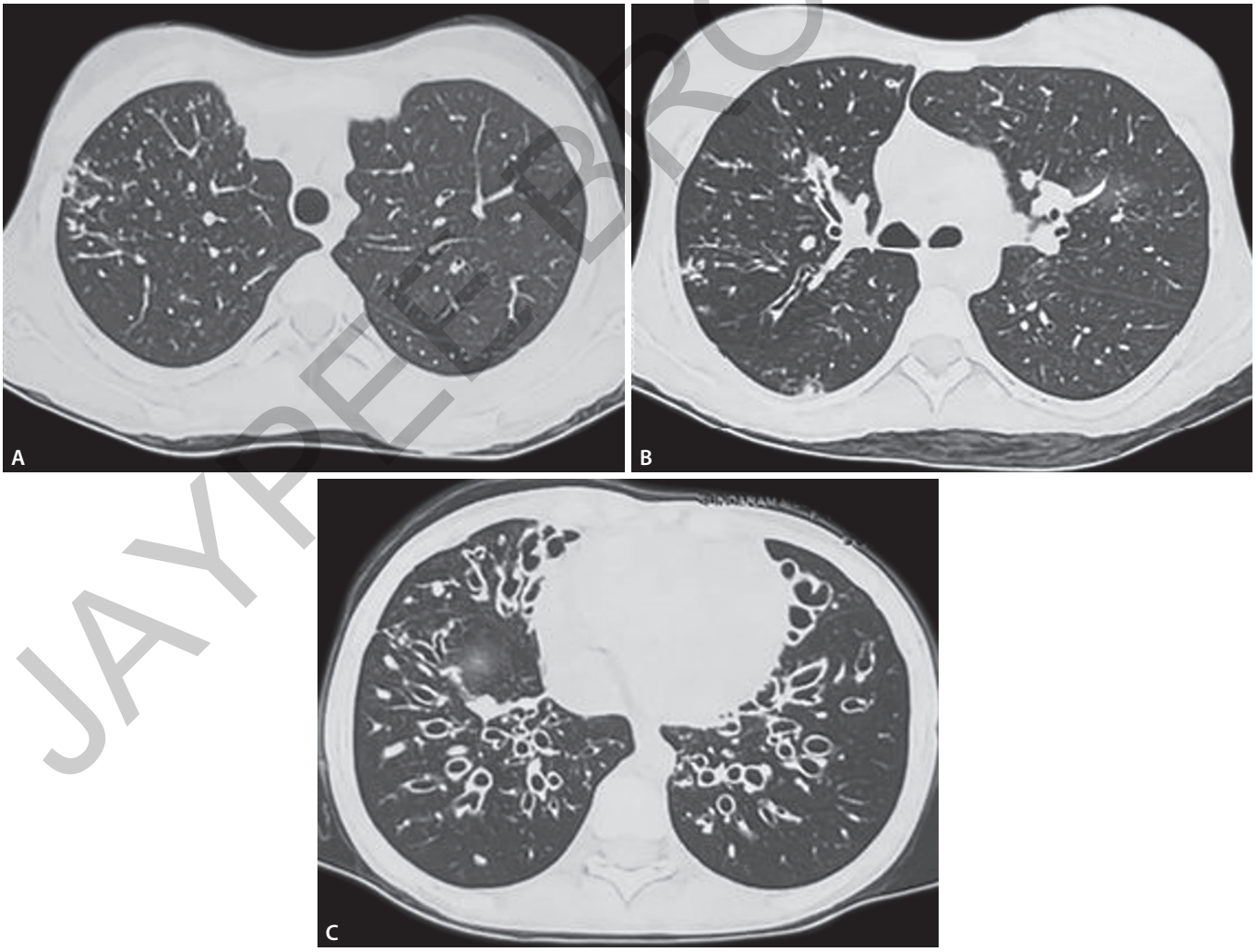
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- *High-resolution computed tomography (HRCT):* Gold standard for diagnosis—earliest investigation to pick-up BT **(Fig. 2A to C)**
  - Signet ring—dilated bronchus is greater than the diameter of the accompanying blood vessel (ratio > 0.8 in children)
  - Failure of airway to taper normally while progressing to lung periphery
  - Tram-track sign—thickened bronchial wall
  - Mucoid plugging or impaction
  - Air fluid levels in distended bronchus
- Bronchography—not used nowadays

- *Evaluation of etiology:*
  - Human immunodeficiency virus (HIV) screening
  - Nucleic acid amplification test (NAAT)/MGIT—in sputum/induced sputum
  - GERD investigation—esophageal pH studies, manometry, and/or upper GI endoscopy
  - *Bronchoscopy:* Missed FB, cartilage defect endobronchial pathology identification, assessment of congenital airway abnormalities and bronchoalveolar lavage when sputum cannot be reliably obtained.
  - Immunoglobulin profile—IgG, IgA, and IgM, IgG subclass for B-cell immunodeficiency, nitroblue tetrazolium test for chronic granulomatous disease (CGD)
  - Sweat chloride by pilocarpine iontophoresis—abnormal > 60 mEq/100 g sweat
  - Barium study—achalasia causing recurrent aspiration
  - Nasal ciliary biopsy—electron microscopy for ultrastructure of cilia, ciliary beat function
- Assessment of severity—pulmonary function test by spirometry

Management

- *General measures:*
  - Improve nutrition
  - Avoid passive smoking, exposure to biofuel
  - Routine and special vaccines especially annual flu vaccination



Figs. 2A to C: Bronchiectasis changes shown in CT.
Source: Personal collection. Dr Sarath Balaji, Pediatric Pulmonologist, Institute of Child Health and Hospital for Children, Madras Medical College, Chennai, Tamil Nadu, India.

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- *Antimicrobial treatment:*
  - Intermittent in acute exacerbation—obtain sputum culture prior to starting antibiotics
  - Long-term maintenance—Azithromycin (can be used as an immunomodulator in CF)
- Bronchial hygiene—most important aspect of management
  - *Airway clearance methods:*
    - Daily chest physiotherapy
    - Facilitate mucus expectoration by manual and mechanical interventions—chest percussion, vibration and postural drainage
  - Cough-assist devices and airway oscillation devices—serve as adjuncts to cough (most effective and efficient manner of clearing airway)
  - *Mucolytic agents:*
    - *Inhaled osmotic agents:*
      - 3% saline (7% saline if available)
      - 7% hypertonic saline
    - Recombinant deoxyribonuclease is efficacious in CF but contraindicated in non-CF BT

- *Treatment of underlying etiology:*
  - Treat as per sputum culture results for present infection
  - Antituberculous treatment if TB
  - Removal of foreign body if present
  - Reduce aspiration by anti-GERD medications and diet modification
  - Immunodeficiency—intravenous Ig, bone marrow transplant based on diagnosis
  - Cystic fibrosis—multipronged approach, clearance of airway secretions, chest physiotherapy and with devices [Acapella—oscillating or vibratory positive expiratory pressure (PEP) device, blowing through a straw in a bottle half filled with bubble solution—can be used as a PEP device, nebulized 3%/7% saline, pancreatic enzyme replacement therapy (PERT), adequate nutrition, lung function assessment, and vitamin fat soluble—supplementation, treatment of acute exacerbation of chronic bronchitis
  - Primary ciliary dyskinesia—treat infection adequately
- *Surgery:* Only in focal BT, lobectomy
  - *Indications:*
    - Poor control of symptoms (purulent sputum and frequent exacerbations) or poor growth, despite optimal medical therapy
    - Severe and recurrent hemoptysis uncontrolled by bronchial artery embolization
  - Contraindications—bilateral BT, young (<6 years) child, minimally symptomatic disease

Complications

- Bronchopneumonia
- Empyema
- Lung abscess
- Hemoptysis
- Metastatic abscess—brain
- Osteomyelitis
- Hemoptysis
- Cor pulmonale
- Amyloidosis

FREQUENTLY ASKED QUESTIONS

1. Mention few suppurative diseases of the lung.
Suppurative disease of the lung—bronchiectasis, lung abscess, and empyema

2. What is the time scale?
Time to develop suppurative disease—empyema—days; lung abscess—days to a week; and bronchiectasis—few weeks to a month

3. What is bronchiectasis?
Definition: Abnormal permanent dilatation of bronchi or subsegmental bronchi with inflammatory destruction of peribronchial tissue (muscle, cartilage) with accumulation of secretions in the dependent bronchi

4. How can bronchiectasis be classified? Which type is reversible?
- Classic Reid classification—three different patterns
- Cylindrical (Tubular) bronchiectasis—mildly uniform airway dilation
- Varicose bronchiectasis—focally dilated areas between narrowed segments
- Saccular bronchiectasis—balloon-like airway dilation with more disruption of lung parenchyma
- Reversible bronchiectasis—can happen with tubular bronchiectasis

5. How to identify clubbing?
- Schamroth sign—obliteration of the quadrangular space when both fingers kept in unison
- Distal phalangeal depth (DPD) to interphalangeal depth ratio (IPD) > 1

6. What are the goals of evaluation?
- Goals of evaluation:
  - To confirm diagnosis of bronchiectasis
  - To identify underlying etiology and any potentially treatable causes
  - To assess severity of pulmonary disease

7. What are the "three layered sputum" seen in bronchiectasis.
Three-layered sputum: When collected in conical flask—three layers:
1. Thin and frothy,
2. Thick and mucopurulent and
3. Opaque with Dietrich's plugs

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IAP Clinical Cases in Pediatrics for Postgraduates

Salient Features

- *Target audience:* MD, DNB, DCH, MRCPCH, pediatric postgraduates as well as pediatric faculty
- Case presentation format is used in this book with more than 50 examination cases
- Highlights in history and important findings in the physical examination are given in a systematic manner, so that candidate can arrive at an appropriate differential diagnosis, which is the most crucial aspect of clinical medicine, both in examination and subsequently in practice
- Relevant clinical notes to understand the basics and also FAQs for quick revision before the examination are included. This book has been authored by experienced postgraduate teaching faculty from MD and DNB stream
- Additional topics included are tips for examination, growth charts, research methodology, interpretation of Chest X-ray, how to use the ophthalmoscope, EEG, ventilator graphics, FAQ in ER and critical care and spirometry
- This book fulfils the oft-felt need of the students and practitioners to have a systematic approach to common pediatric cases, especially in the Indian context.

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