LUNG SOUNDS
Windpipe (trachea)
Lung
Bronchus
• Bronchus lumen that air has to pass away
Normal Sound = Breath Sound

• Produced by TURBULENT FLOW in the larger airways → creates audible vibrations in the airways → producing sounds → transmitted through the lung & Chest wall → it is altered by Normal lung (normal lung tissue act as low-pass filter → Attenuation (diff between bronchial & Vesicular))
Patterns of Airflow

Laminar flow occurs mainly in small peripheral airways where rate of airflow through any airway is low. Driving pressure is proportional to gas viscosity.

Turbulent flow occurs at high flow rates in trachea and larger airways. Driving pressure is proportional to square of flow and is dependent on gas density.

Transitional flow occurs in larger airways, particularly at branches and at sites of narrowing. Driving pressure is proportional to both gas density and gas viscosity.

Poiseuille’s law. Resistance to laminar flow is inversely proportional to tube radius to the 4th power and directly proportional to length of tube. When radius is halved, resistance is increased 16-fold. If driving pressure is constant, flow will fall to one-sixteenth. Doubling length only doubles resistance. If driving pressure is constant, flow will fall to one-half.

\[ r = 2 \]
Resistance ~1

\[ r' = 1 \]
Resistance ~16

\[ L = 2 \]
Resistance ~2

\[ L' = 4 \]
Resistance ~4
Auscultation of the lung

- listening for sounds produced in the lung to identify normal or abnormal lung sounds
- a stethoscope is designed for better transmission of sounds to the examiner
- the room should be quite
- vesicular or normal, bronchovesicular, tracheal, bronchial
ABNORMAL Breath Sounds

BRONCHIAL

• The Lung Increases in density (Pneumonia, atelectasis) : Vesicular → Bronchial

• Normal air filled lung becomes Consolidated → Attenuation reduced → similar sound (upper large airways & Consolidated lung)
Abnormal Breath Sounds

**Diminished Breath sounds**

- Intensity of sound at the site of generation (larger airways) is reduced. Ex: shallow or slow breathing pattern
- Increase Attenuation. Ex: Hyper inflated lung tissue, Obstructed airways (mucus plug)
- Reduce transmission of breath sounds through the chest wall. Ex: Air or fluid in pleural space, obesity
### Characteristic of Normal Breath Sounds

<table>
<thead>
<tr>
<th>Breath Sound Diagram</th>
<th>Pitch</th>
<th>Intensity</th>
<th>Location</th>
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<tbody>
<tr>
<td>Vesicular/normal</td>
<td>Low</td>
<td>Soft</td>
<td>Peripheral Lung</td>
</tr>
<tr>
<td>Bronchovesicular</td>
<td>Mod</td>
<td>Mod</td>
<td>Around upper part of Sternum, between Scapular</td>
</tr>
<tr>
<td>Tracheal</td>
<td>High</td>
<td>Loud</td>
<td>Over Trachea</td>
</tr>
<tr>
<td>Characteristics of Breath Sounds</td>
<td></td>
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<tr>
<td>----------------------------------</td>
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</tr>
<tr>
<td><strong>Duration of Sounds</strong></td>
<td><strong>Intensity of Expiratory Sound</strong></td>
<td><strong>Pitch of Expiratory Sound</strong></td>
<td><strong>Locations Where Heard Normally</strong></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>Vesicular</strong></td>
<td>Inspiratory sounds last longer than expiratory ones.</td>
<td>Soft</td>
<td>Relatively low</td>
</tr>
<tr>
<td><strong>Broncho-vesicular</strong></td>
<td>Inspiratory and expiratory sounds are about equal.</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td><strong>Bronchial</strong></td>
<td>Expiratory sounds last longer than inspiratory ones.</td>
<td>Loud</td>
<td>Relatively high</td>
</tr>
<tr>
<td><strong>Tracheal</strong></td>
<td>Inspiratory and expiratory sounds are about equal.</td>
<td>Very loud</td>
<td>Relatively high</td>
</tr>
</tbody>
</table>
A. Anterior Bronchovesicular
B. Posterior Bronchovesicular
C. Anterior Vesicular
D. Posterior Vesicular
Normal Air-Filled Lung

Airless Lung, as in Lobar Pneumonia

**Breath Sounds**
- Predominantly vesicular

**Transmitted Voice Sounds**
- Spoken words muffled and indistinct
- Spoken “ee” heard as “ee”
- Whispered words faint and indistinct, if heard at all

**Tactile Fremitus**
- Normal

**Bronchial or bronchovesicular sound over the involved area**
- Spoken words louder, clearer (*bronchophony*)
- Spoken “ee” heard as “ay” (*egophony*)
- Whispered words louder, clearer (*whispered pectoriloquy*)
- Increased
Auscultation of the lungs

Adventitious sounds: abnormal lung sounds superimposed on normal Sounds

**discontinuous: cracles**

**continuous: wheeze, stridor, ronchi (low pitch wheeze)**
<table>
<thead>
<tr>
<th>Acoustic Characteristics</th>
<th>American Thoracic Society Nomenclature</th>
<th>Common Synonyms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Vesicular</td>
</tr>
<tr>
<td>200–600 Hz</td>
<td>Bronchial</td>
<td>Bronchial</td>
</tr>
<tr>
<td>Decreasing power with increasing Hz</td>
<td></td>
<td>Tracheal</td>
</tr>
<tr>
<td>75–1600 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat until sharp decrease in power (900 Hz)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adventitious</td>
<td>Adventitious</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Discontinuous, interrupted explosive sounds (loud, low in pitch), early inspiratory or expiratory</td>
<td>Coarse crackle</td>
<td>Coarse rale</td>
</tr>
<tr>
<td>Discontinuous, interrupted explosive sounds (less loud than above and of shorter duration; higher in pitch than coarse crackles or rales), mid- to late inspiratory</td>
<td>Fine crackle</td>
<td>Fine rale, crepitation</td>
</tr>
<tr>
<td>Continuous sounds (longer than 250 msec, high-pitched; dominant frequency of 400 Hz or more, a hissing sound)</td>
<td>Wheeze</td>
<td>Sibilant rhonchus</td>
</tr>
<tr>
<td>Continuous sounds (longer than 250 msec, low-pitched; dominant frequency about 200 Hz or less, a snoring sound)</td>
<td>Rhonchus</td>
<td>Sonorous rhonchus</td>
</tr>
</tbody>
</table>
Figure 5-22 Time-expanded waveforms demonstrating inspiratory crackles (A) and expiratory polyphonic wheezes (B). (Modified from Wilkins RL et al: Lung sound terminology used by respiratory care practitioners, Respir Care 34:36, 1989.)
Wheezeing

• Continuous ALS, easy recognized
• Generated by →

*Vibration of the Walls of Narrowed or Compressed airway as air passed through at high velocity*

• The pitch of Wheeze independent of the length of the airway BUT related directly to the degree of airway compression.
• The tighter compression → the higher of the pitch
Airway diameter reduced may be caused by Bronchospasm, mucosal edema, foreign object, compression extra lumen.
Wheezeing

• When Wheeze identified → Note : pitch, intensity, the portion of respiratory cycle occupied by wheezing

• >> Narrowing → ↑↑ pitch, >> intensity (louder) and > in portion of respiratory cycle occupied (inspiration & expiration).

• Improvement airway caliber → ↓ pitch, < intensity, < respiratory cycle occupied (expiration only)
STRIDOR

• Life threatening sign
• Mechanism $\rightarrow$ WHEEZING

$\leftarrow \rightarrow$ Rapid airflow through a Narrow site of upper airway produce Vibration of lateral walls $\rightarrow \uparrow \uparrow$ pitch sound, often heard without stethoscope

• Narrowed upper airways may be caused by infection (croup, epiglotitis), inflammation following extubation
STRIDOR

• Most often heard during inhalation because:
  Upper airway tends to narrow with significant inspiratory efforts

• When severe obstruction & fixed (airway opening not vary with breathing) → Stridor Inspiratory & Expiratory
Continuous ALS, Low pitched

• Ronchi = Ronchus (Ronki kering)

• Low pitched continuous sounds associated with

  Presence excessive sputum in the airways →
  A sputum flap vibrating in the airstream → low pitched wheezes, clear after patient cough
CRACKLES

- Discontinuous ALS
- Produced by movement of excessive secretions or fluid in the airways as air passes through → Coarse crackles, heard during Inspiration and expiration. Often clear if the patient cough
- Crackles: without excessive secretions, but collapsed airways pop open during inspiration → Produce explosive equalization of pressure between collapse & patent airways.

Airway closure may occur in *peripheral bronchioles* or more proximal *bronchi*
CRACKLES

• *Crackles in Early inspiratory*: larger, more proximal bronchi close during expiration (caused by ↑ bronchial compliance or low retractive pressure around the bronchi) → ex in COPD, asthma, emphysema
CRACKLES

- **Crackles occur late in inspiratory phase**: Peripheral alveoli & airways close during exhalation caused by ↑ surrounding intrathorax pressure. Crackles produced by sudden opening of periphearl airways ususualy occurs late in inspiration phase.

May clear with changes posture, or several deep inspiration. Coughing or maximal exhalation produce reappearance of late inspiratory crackles

Ex. **Pulmonary edema**, fibrosis that reduce lung volume, atelectasis, pneumonia
Mechanism of Late inspiratory Crackles. Peripheral airways pop open when inspiratory effort is sufficient to overcome the forces causing the atelectasis.
PLEURAL FRICTION RUB

• Creaking or grating type of sound, occurs when pleural surfaces become inflamed and the roughened edges rub together during breathing.
• May be heard during inhalation only but often in both (Inspiratory & Expiratory).
• Sound similar to Coarse crackles BUT not affected by coughing.
• Intensity of pleural rubs may ↑ when deep breathing.
Adventitious Lung Sounds (ALS)

- Continuous
  (continuous sounds)

- Discontinuous
  (intermittent, crackling, bubbling sound, short duration)
Wheezing

• Continuous ALS, easy recognized
• Generated by *Vibration of the Walls of Narrowed or Compressed airway as air passed through at high velocity*
• The pitch of Wheeze independent of the length of the airway BUT related directly to the degree of airway compression.
• The tighter compression → the higher of the pitch
Airway diameter reduced may be caused by Bronchospasm, mucosal edema, foreign object, compression extra lumen.
Wheezeing

- When Wheeze identified, Note: The pitch, Intensity, the portion of respiratory cycle occupied by wheezing
- More Narrowed airway caliber $\rightarrow$ higher pitch, increase intensity (louder) and increase in the portion of respiratory cycle occupied (inspiration & expiration).
- Improvement airway caliber (ex. by treatment), decrease pitch, decrease intensity, decrease respiratory cycle occupied (expiration only)
STRIDOR

• Life threatening sign
• Mechanism similar to WHEEZES
  → Rapid airflow through a Narrow site of upper airway produce Vibration of lateral walls → High pitch sound, often heard without stethoscope
• Narrowed upper airways may be caused by infection (croup, epiglottitis), inflammation following extubation
STRIDOR

• Most often heard during inhalation because:
  Upper airway tends to narrow with significant inspiratory efforts.

• Stridor Inspir & Expir: When severe obstruction and fixed (airway opening not vary with breathing)
Continuous ALS, Low pitched

- Ronchi = Ronchus (Ronki kering ?)

- Low pitched continuous sounds associated with *Presence excessive sputum in the airways* → A sputum flap vibrating in the airstream → low pitched wheezes, clear after patient cough
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<table>
<thead>
<tr>
<th>Recommended Term</th>
<th>Classification</th>
<th>Other Term used</th>
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<tbody>
<tr>
<td>Crackles</td>
<td>Discontinuous</td>
<td>Rales</td>
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<tr>
<td></td>
<td></td>
<td>Crepitations</td>
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<tr>
<td>Wheezes</td>
<td>High-pitched</td>
<td>Sibilant rales</td>
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<tr>
<td></td>
<td>Continuous</td>
<td>Musical rales</td>
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<tr>
<td></td>
<td></td>
<td>Sibilant ronchus</td>
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<tr>
<td></td>
<td>Low-pitched</td>
<td>Sonorous rales</td>
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<tr>
<td></td>
<td>Continuous</td>
<td>Rhonchi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INDO : Ronki kering</td>
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<tr>
<td></td>
<td>Consolidation</td>
<td>Pleural effusion</td>
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<tr>
<td>Mediastinal shift</td>
<td>No</td>
<td>No or away</td>
</tr>
<tr>
<td>Chest wall excursion</td>
<td>Normal or decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Percussion note</td>
<td>Normal or decreased</td>
<td>Decreased (stony)</td>
</tr>
<tr>
<td>Breath sounds</td>
<td>Increased (bronchial)</td>
<td>Decreased</td>
</tr>
<tr>
<td>Added sounds</td>
<td>Crackles</td>
<td>Rub (occasional)</td>
</tr>
<tr>
<td>Tactile vocal fremitus/vocal resonance</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
</tbody>
</table>