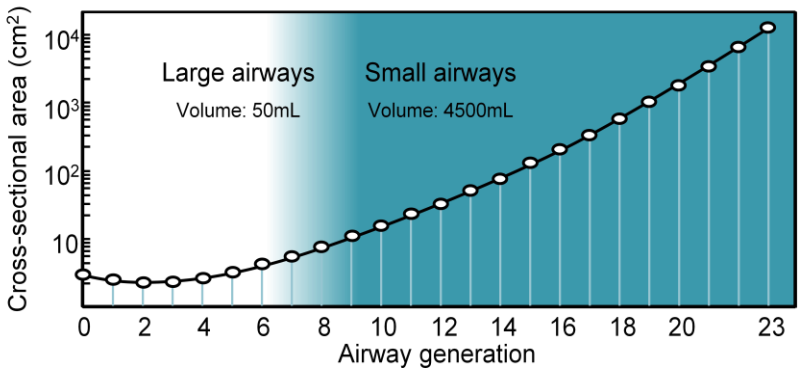
Unit II – Problem 3 – Physiology: Bronchomotor Tone

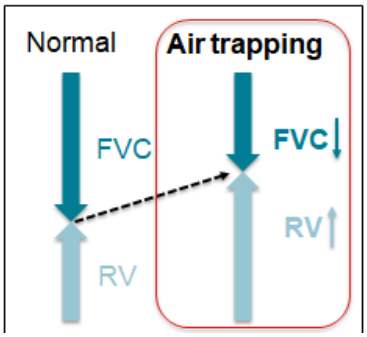
- **The bronchial tree in the lung is divided into two zones:**
  - **Conducting zone**: these are the first 16-17 branches (trachea, main bronchi, lobar bronchi, segmental bronchi and terminal bronchioles) which transport air into smaller airways.
  - **Respiratory zone**: these are the lower 6-7 branches (respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli) and are considered as the site for gas exchange. Notice that small airways (which are less than 2mm in diameter) constitute 98% of total lung volume. Therefore, inflammation of small airways is likely to have a large impact on lung function.



- **Rate of airflow can be calculated as the following:**
  - **Rate of airflow** = $\frac{\text{Pressure difference (between alveoli and atmosphere)}}{\text{Resistance}}$
- **What are the factors which affect airflow into and out of the lungs?**
  - Lung compliance.
  - Airway resistance.
  - Alveolar surface tension.
- **What are the factors which affect airway resistance?**
  - **Size of the airways**: resistance is more in larger airways (in contrast to smaller airways which are numerous with a larger surface area). The medium-sized bronchi (2-4 mm in diameter) are considered to have the highest resistance.
  - **Smooth muscle contraction**: contraction of these muscles produce smaller lumen of airways with more resistance. The effect of smooth muscle contraction is less on larger airways due to the presence of C-shaped cartilages which are preventing contraction.
  - **Any condition which narrows or obstructs the airway (mucous plug, edema… etc) results in increased resistance.**
- **Airflow resistance is lower during inspiration and higher during expiration:**
  - **With inspiration**, there is increase in diameter of small airways and hence a reduction in airway resistance.
  - **With expiration**, diameter of small airways reduces leading to increased airway resistance.
- **Respiratory passageways:**
  - Mucous present in respiratory tract humidifies and traps foreign particles.
  - Ciliated epithelium of respiratory tract moves mucous towards the pharynx (thus clearing the airways).
- **Cough and sneeze reflexes:**
  - **Cough reflex:**
    1. 2.5 L of air is inspired rapidly.
    2. Epiglottis closes and vocal cords adduct to keep air trapped in the lungs.
    3. Abdominal muscles will contract forcefully pushing the diaphragm upwards against the lungs thus increasing their pressure.
    4. Epiglottis and vocal cords open suddenly and cough occurs.

- **Sneeze reflex**: same as cough reflex except that uvula will be depressed when epiglottis and vocal cords open suddenly so air passes rapidly through the nose (clearing nasal cavity from foreign bodies).

- **Small airway function measurement:**
  - **Obstructive lung diseases in which air is trapped in the lungs will decrease Forced Vital Capacity (FVC) while increasing the Residual Volume (RV). This may be assessed by several methods including:**



    - ✓ Residual Volume (RV) and Forced Expiratory Flow (FEF): if they are between 25-75% of Forced Vital Capacity (FVC), they reflect peripheral abnormalities.
    - ✓ Exhaled Nitric Oxide (eNO): it is considered as a biomarker of small airway inflammation. Nitric oxide is produced from L-argenine by Nitric Oxide Synthase (NOS):
      - ❖ Neuronal (nNOS).
      - ❖ Inducible (iNOS).
      - ❖ Endothelial (eNOS): patients with asthma have higher eNO levels than other people, but eNO might also increase in:
        - ➢ Other upper respiratory tract infections.
        - ➢ Exposure to allergens (thuja and cypress resin).

        Notice that steroids and leukotriene receptor antagonists reduce eNO level.
    - ✓ Impulse oscillometry: as the patient breathes through a machine, a sound wave generated by a loudspeaker is superimposed over his breathing. The patient's airflow and sound wave response is transmitted to the apparatus and used to calculate the various components of resistance to breathing

- **Bronchiolar smooth muscles contract in response to:**
  - **Parasympathetic stimulation**: few parasympathetic fibers from vagus nerve reach the lungs. irritation by noxious gases, dust, cigarette smoking or bronchial infection results in bronchoconstriction.
  - **Release of leukotriens and histamine.**
  - **Cold air.**
  - **Chemical neural stimulation (via neurokinins and substance P).**
- **Bronchiolar smooth muscles relax in response to:**
  - **β_2-adrenergic stimulation**: epinephrine and NE are strong stimulators of β-adrenergic receptors in bronchioles causing bronchodilation. Notice that few sympathetic nerve fibers reach the lung so stimulation by sympathetic nerve fibers is weak.
  - **Chemical neural stimulation (via vasoactive intestinal peptide VIP).**
  - **Warm and humidified air.**
- **Hypoxia:**
  - **Definition**: condition in which the body or a region of the body is deprived of adequate oxygen supply.
  - **Types:**

Inadequate oxygenation	• Low oxygen in atmosphere. • Hypoventilation in neuromuscular disease.
Pulmonary disease	• Hypoventilation due to increased airway resistance of fibrosis. • Abnormal ventilation-perfusion ratio. • Diminished respiratory membrane diffusion.
Venous to arterial shunts	• Right to left cardiac shunts

Inadequate oxygen transport to the tissue by blood	• Anemias. • Circulatory insufficiency. • Localized circulatory problems like cerebral or coronary vessels. • Tissue edema.
Inadequate tissue capability to use oxygen	• Cyanide toxicity

- **Oxygen therapy:**
  - ✓ Useful for atmospheric and hypoventilation hypoxia, but not so good for anemia. It is not useful at all for cyanide poisoning.
  - ✓ How much to give? Normally about 30% is given in hospital settings. High concentrations of oxygen cause high concentrations of oxygen free radicals which destroy cell membrane (resulting in toxicity).