Q18 Describe the factors that affect airway resistance (March 2009)

- Airways resistance → frictional resistance to airflow through a tube
- Usual value in healthy subjects is 0.5-2cmH_2O/L/sec

FACTORS AFFECTING AIRWAYS RESISTANCE:

1. NATURE OF GAS FLOW
    - Defined by Reynolds number (Re) = Dvp/n (where D = diameter, v = velocity, p = gas density and n = gas viscosity). <2000 is usually laminar flow, 2000-4000 transitional, and >4000 usually turbulent flow (hence in larger airways with greater velocity and radius, turbulent flow is more likely)

    - Laminar flow
        - Describes gas flowing along a straight unbranched tube as a series of concentric cylinders which slide smoothly over one another, with the central cylinder the fastest, producing a cone-shaped front
        - Driving pressure is proportional to flow rate P=KV
        - Hagen-Poiseuelle's law gives: flow = $\Delta P \pi r^4 / 8nl$ (where n = viscosity, l = airway length and r = radius)
        - As Q = ΔP/R (Ohm's Law), rearranging gives resistance = $8nl / \pi r^4$
        - Hence, decreasing radius by (x) increases the resistance by (x^4). As the smaller airways exist in parallel, overall resistance in small airways is actually low. Most resistance occurs at the medium sized airways up to the seventh generation of bronchi (note that in neonates, a greater proportion of R_{aw} comes from the smaller peripheral airways)

    - Turbulent flow
        - Describes multiple eddy currents all moving in roughly the same direction (tends to occur in larger airways)
        - Driving pressure is proportional to $(\text{gas flow})^2$ ie, $P = KV^2$

    - Transitional flow
        - In most of the bronchial tree, flow is transitional, meaning driving pressure determined by both the flow rate and its square: $P = K_1V + K_2V^2$

2. GAS COMPOSITION
    - As per Poiseuelle and Reynold's – changes in gas density or viscosity affect R_{aw}. (Hence divers breathe helium mixtures as helium is 8 times less dense than oxygen, thus reducing R_{aw} associated with breathing compressed air)

3. AIRWAY SIZE
    - As per Poiseuelle – any reduction in radius increases airways resistance by a factor of 4. Can classify causes as:
        - A decrease in intraluminal area (mucous, oedema, SOL, fibrosis etc)
        - An increase in smooth muscle tone (bronchospasm, drugs)
        - External compression of airway (mass, hemorrhage, pneumothorax, dynamic airways compression)

4. LUNG VOLUME
    - Airways are held open by the radial traction of surrounding lung parenchyma. Increasing lung volumes increases airway size and reduces R_{aw} (and vice versa). Hence R_{aw} varies throughout the respiratory cycle

5. NERVOUS FACTORS
    - Contribute to bronchial tone (sympathetic stimulation reduces tone, cholinergic increases)

6. CHEMICAL FACTORS
    - Endogenous (histamine, adrenaline, leukotrienes, PACO2) and exogenous (B2 agonists, antimuscarinics)