**Alveolar gas equation (AGE) and altitude viva**

Alex Hunter 2020

*Opening question read exactly:*

**Q) How can we calculate the partial pressure of alveolar oxygen?**

The partial pressure of alveolar oxygen cannot be sampled or estimated from end expired gas due to mixing with gas from alveolar dead space.

The **Alveolar Gas Equation** allows us to calculate the partial pressure of oxygen in the alveolus.

**Q) Define the Alveolar Gas Equation**

Partial pressure of alveolar oxygen = Inspired partial pressure of oxygen – (Partial pressure of alveolar CO2/ Respiratory quotient)

PAO2 = PiO2 – (PACO2/R)

Q) if not already done **Define PiO2**

where PiO2 = FiO2 x (Barometric pressure – Saturated vapour pressure of water

@ 37 degrees Celsius)

**Q) What is the respiratory quotient?**

R = CO2 produced/O2 consumed in unit time (at a cellular level)

**Q) what is R dependent on?**

R is dependent on diet

Candidates should be able to give some examples:

Typical R values

Fats 0.7

Protein 0.8-0.9

Carbs 1

Typical average ~ 0.8

**Q) What assumptions are made by the alveolar gas equation?**

1. PaCO2 = PACO2,
2. the fact that alveolar and arterial CO2 are less affected by changes in https://portal.e-lfh.org.uk/ContentServer/content/ANA_07b_053/png/v_normal.png/https://portal.e-lfh.org.uk/ContentServer/content/ANA_07b_053/png/q_normal.png ratio

The candidate should understand that the term PACO2 in the AGE is therefore approximated to equal PaCO2

**Q) What is a normal PAO2 in kPa?**

14kPa

**Q) Can you give examples of factors affect PAO2?**

1. Changes in FiO2 (eg *altitude*)
2. Rising PaCO2 (eg hypoventilation)
3. Changes in R (eg diet)

**“We are now going to talk about altitude”**

**Q) How would the partial pressure of alveolar oxygen be affected by altitude?**

Barometric pressure @ 5000m approx 50kPa ie half that at sea level.

Thus as PiO2 = FiO2 x (PBaro – PH20)

FiO2 is constant. (21%)

PH20 is SVP of water at body temp (37deg). Assuming climber body temp = 37. This also remains constant.

Hence//

PiO2 reduced by a fall in barometric pressure.

The candidate should be able to clearly explain the above.

Extra info

At 8848m summit Everest approximately 1/3 sea level partial pressure

One of the lowest documented arterial partial pressures of oxygen PaO2 in a healthy individual is 2.55 kPa, which was taken at 8400 m on Everest from Professor Dan Martin.

**Q) What physiological adaptation occur during an altitude acclimatisation process?**

Respiratory changes:

1. Increased alveolar ventilation. Mechanism complex – do not ask. Driven in part by peripheral chemoreceptors.
2. Resultant respiratory alkalosis.
3. Decreased A-a gradient.
4. Oxygen-Hb dissociation curve.

* Acutely left shift from hyperventilation and resultant resp alkalosis
* Over days to weeks, increased 2,3DPG cause rightward correction returning to sea level position in fully acclimitized individuals.

Cardiac changes

1. Increased cardiac output driven by sympathetic nervous system. Primarily achieved by an increase in HR.

Haematological changes

1. Increased Hb to increase arterial oxygen content of blood.

by a) acutely – reduction in plasma volume to haemoconcentrate

b) within hours – increase EPO production

Renal

1. Bircarbonate loss secondary to respiratory alkalosis.
2. EPO increase as above.

**Q) What is mountain sicknees?**

Acute Mountain Sickness (AMS) usually occurs above 6000ft. When mild, may cause dyspnoea, headache, nausea, fatigue and sleep disturbance associated with CheyneStokes respiration.

The severity of AMS is related to the speed of ascent as 25 % of tourists arriving in the Andes by air suffer mountain sickness cf less in climbers who have a slower rate of ascent.

Severe AMS

High altitude pulmonary oedema (HAPO) associated with exercise and caused by excessive

pulmonary vasoconstriction. 1% of climbers suffer and there is a high mortality if untreated.

Symptoms include a persistent cough productive of a white, watery or frothy fluid.

High Altitude Cerebral Oedema (HACO) where the individual may suffer a coma or

hallucinations.

TREATMENT: Immediate descent and nifedipine or acetazolamide.

Chronic Mountain Sickness is found in populations living at altitude. Symptoms/Signs include:

Poor hypoxic response to ventilation

CO2 retention

Polycythaemia

Cyanosis

Clubbing

References

Direct candidates to:

* My e-Learning -> Anaesthesia (e-LA) Core Training -> Basic Sciences -> e-LA Module 07b - Physiology Respiratory Physiology
* My e-Learning -> Anaesthesia (e-LA) -> Core Training - Exam Preparation -> Revision Guides
* Humans at altitude: physiology and pathophysiology Brown, Grocott. doi:10.1093/bjaceaccp/mks047