Physiology week 14 – Respiratory (control) VIVAs

TOPIC: Altitude on respiration ______________________NUMBER:

OPENING QUESTION	What is the initial effect on respiration with ascent to 6000 metre	**PROMPTS**
POINTS REQUIRED	1. (where the ambient pressure is about half the atmospheric pressure)	1
	2. hyperventilation	2
	3. Shift of the oxygen dissociation curve to the right	3
	4.	4
SECOND QUESTION (if needed)	If the person remains at the same altitude for 6 months, what additional changes would occur?	
POINTS REQUIRED	1. Polycythaemia	1
	2. Increase in 2,3 DPG	2
	3. Increase in the number of capillaries in peripheral tissues	3
	4. Increase maximal breathing capacity	4
	5. Pulmonary vasoconstriction resulting in pulmonary hypertension and right ventricular hypertrophy	5
	7	
THIRD QUESTION (if needed)	Describe the symptoms of acute mountain sickness.	
POINTS REQUIRED	1. headache, fatigue, dizzy, palpitations, nausea, loss of appetite & insomnia.	1
	2.	2

TOPIC: Control of ventilation______________________ NUMBER: _

OPENING QUESTION	Where are the peripheral chemoreceptors involved in control of ventilation?	**PROMPTS**
POINTS REQUIRED	1 Carotid bodies near carotid bifurcations	1 O^2 sensor?
	2 One or more near arch of aorta	2
	3 (Carotid bodies more important)	3
	4	4
	5	5
SECOND QUESTION (if needed)	What is their role?	
POINTS REQUIRED	1 Sense O^2, CO^2, H^+ concentrations	1 Tell us more about the specific substances that stimulate chemoreceptors?
	2 Feedback to medullary respiratory centre	2
	3 O^2 sensor critical to response to hypoxia	3
	4 pO^2 less than 60 gives inc ventilation	4
	5 CO^2 less important (but faster than central)	5
	6 H^+ (carotid b) gives inc vent if pH falls	6
	7	
THIRD QUESTION (if needed)	Where are the central receptors involved in ventilation and what do they respond to?	
POINTS REQUIRED	1 Medulla	1 Brain sensors?
	2 Respond to pH of CSF	2
	3 Indirectly respond to CO^2	3

TOPIC: Respiratory system and exercise ______________ NUMBER: _

OPENING QUESTION	In the respiratory system, what changes occur with exercise?	**PROMPTS**	
POINTS REQUIRED	1 Inc O^2 demand and CO^2 production	1 Any changes?	
	2 Inc ventilation rate, tidal vol, minute vol	2	
	3 Inc pulmonary blood flow	3	
	4 More even V/Q ratios	4	
	5 Dec physiological dead space	5	
	6 Greatly inc O^2 uptake and CO^2 offloading	6	
	7 (Mean ABGs do not change until late)	7	
	8		
SECOND QUESTION (if needed)	What happens to the pulmonary circulation during exercise?		
POINTS REQUIRED	1 Flow increases	1 Vs arterial?	
	2 Distension, recruitment of vessels	2	
	3 Inc cross-sectional area	3	
	4 Thus pressures fall	4	
	5	5	
	6	6	
	7		
THIRD QUESTION (if needed)	What changes occur in venous gases during exercise?		
POINTS REQUIRED	1 Total CO^2 carried rises	1 Vs arterial?	
	2 Dec O^2 because inc extraction	2	
	3 Lactic acidosis	3	
	4	4	

Effect of altitude on respiration	What are the acute respiratory adaptations to altitude? What are the longer term physiologic effects of altitude exposure?	Hyperventilation. (Oxygen-haemoglobin curve shifts right or left.) Polycythaemia; one of increased O_2 carriage and viscosity; RVH; more capillaries; increased oxidative enzymes.
Control of ventilation.	What are the basic elements of the respiratory control system? What inputs are there into the respiratory control system? Explain the function of the central chemoreceptors	Sensors; Central Controller; Effectors. Cortical Central and peripheral chemoreceptors, Lung and other receptors. Respond to changes in H^+ concentration. CO_2 regulates ventilation by effects on pH

Describe the effect of high altitude on respiration. *Prompt if required:* *Explain the mechanism underlying hyperventilation at altitude.*	*Hyperventilation Most important factor in acclimatisation to altitude. *Mechanism: Hypoxic stimulation of peripheral chemoreceptors [carotid bodies, aortic bodies]. Low pCO2 and alkalosis work against this but CSF pH 'normalised' by movement of bicarbonate out of CSF [~1-2 days] and renal excretion of bicarbonate [2-3 days] 'normalises' arterial pH taking this brake off. Sensitivity of carotid bodies to hypoxia increases during acclimatisation.	Hyperventilation plus mechanism
What other processes are involved in acclimatisation to high altitude?	*Polycythaemia [hypoxia, erythropoietin] Shifts in the O2 dissociation curve Right at moderate altitude 2° 2,3 DPG favouring unloading in tissues; left at high altitude 2° respiratory alkalosis favouring loading in lungs. Changes in capillary numbers/ density Changes to oxidative enzymes in cells Increased maximum breathing capacity	Polycythaemia with mechanism One other

TOPIC: Control of Ventilation ____________________ NUMBER: __________

OPENING QUESTION	**What is the role of central chemoreceptors in control of ventilation?**	**COMMENTS**
POINTS REQUIRED	1. Located near ventral surface of medulla	
	2. Rise in blood CO2 increases CO2 in CSF	
	3. CSF has poor buffering capacity so pH changes rapidly	Bolded to pass
	4. Liberated H^+ ions stimulate chemoreceptors (increasing pH has reverse effect)	
	5. Efferents stimulate medullary respiratory centre to increase ventilation and return CO2 to normal.	
	6. Chronic CO2 elevation gives normal CSF pH and insensitivity	
PROMPTS	What happens in the brain when the blood CO2 level rises?	
SECOND QUESTION (if needed)	**What is the role of the peripheral chemoreceptors?**	
POINTS REQUIRED	1. Located in carotid and aortic bodies that have high blood flow	
	2. Respond mostly to decrease in O2 below 100mmHg	
	3. Impulses transmitted to respiratory centre to increase ventilation	3 of 5 to pass
	4. Responsible for all of the ventilatory response to hypoxaemia	
	5. Also responsible for small but rapid response to rise in CO2 and decrease in pH (carotid bodies)	
PROMPTS	How is hypoxaemia detected?	

TOPIC: Ventilation Perfusion Inequality________________

OPENING QUESTION	**What is the effect of ventilation perfusion inequality on gas exchange?**	**COMMENTS**
POINTS	Impedes exchange of oxygen and carbon dioxide	need 2/3
	Hypoxia which cannot be corrected by increased ventilation	
	Hypercapnia can be corrected by increased ventilation	
PROMPTS	**Both gases**	
SECOND QUESTION	**Can increasing ventilation correct these problems?**	expect oxygen explanation Others additional information
POINTS	The oxygen dissociation curve is S shaped which means that increasing ventilation to units with high VQ ratios cannot compensate for the shunt caused by low VQ units	
	The carbon dioxide dissociation curve is more linear so that increasing ventilation will blow off CO2 from lung units with both high and low VQ ratios	
PROMPTS	**Both gases**	
THIRD QUESTION	**How can we determine the effect of VQ mismatch on oxygenation in clinical practice?**	
POINTS	Calculate the AA gradient = PAO2-PaO2	Prefer equation
	PAO2=PIO2-PaCO2/R	
	Give normal values for each	
PROMPTS	**Ask about AA gradient if candidate does not volunteer it**	

1.1 VP inequality (West pp 67-72)	Describe the relationship between ventilation and perfusion of the lung in a person while standing?	• Max ventilation 3-4x greater at apex • PO_2 40mmHg higher at lung apex • Max perfusion basally Q nearly 20x greater at base • Prompt: are there regional variations in either
	What are the effects of V/Q inequality on gas exchange?	• V/Q inequality impairs uptake or elimination of all gases • Majority of blood returns from lung bases where the oxygen saturation is low • Results in blood PO2 being lower than that of mixed alveolar PO2
	What effect does increasing ventilation to the lungs have on arterial PO2 and PCO2	• PCO2 reduces much more than PO2 increases

Question 2:	**What are the physiological changes that allow survival at high altitude ?**	1) Hyperventilation > decreases CO_2, > O2 2) Increased Hb (> EPO), 3) Alkalosis moderated by movement of bicarbonate from CNS (1-2/7) and renal excretion 4) Increased 2,3,DPG - R shift, 5) Pulm hypertension (due to alveolar hypoxia inducing pulm vasoconstriction) - 6) RV hypertrophy – not really an "adaptation" 7) Decreased work of breathing	All hypoxia driven, > viscosity helpful as pick up more difFic (3 of 7 to pass)

TOPIC: Sensors in control of ventilation______________ **NUMBER:** __________

OPENING QUESTION	What sensors are involved in control of ventilation?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	• Mainly **chemoreceptors** • Also mechanical receptors • Many others incl stretch, irritant, pain	What senses changes in blood gases?	
	Central chemoR in medulla respond to H^+ : • Located separate from the dorsal and ventral respiratory neurons on the ventral surface of the medulla. • Monitor **H+ concentration of CSF**. (CO2 readily penetrates blood brain barrier whereas H+ and HCO3- penetrate slowly. CO2 promptly hydrated to H2CO3, which dissociates to H+ and HCO3.) • CSF has a much lower buffering capacity than blood and as a result change in pH for a given change in pCO2 is **greater**. Change in pH also occurs **more quickly.**	Where are the chemoreceptors found?	Need peripheral and central chemoR. Others just for bonus points. [JB]
	Peripheral chemo in carotid and aortic bodies respond to O2, CO2, H^+ : • **Carotid bodie**s most important in humans - located at bifurcation of carotid artery. 2 or more aortic bodies in arch of aorta. • Receptors stimulated by a rise in pCO2, H+ or a fall in pO2 – **they are most sensitive to pO2** and are the most important regulator in hypoxia. • Sensitivity to arterial pO2 begins at 500mmHg though relatively little response occurs until below 100mmHg. Blood flow per gram of tissue is enormous – 2000ml/100g of tissue. They have a high metabolic rate but arterial and venous oxygen difference is very small. Type I (glomus) cells closely associated with afferent nerves. Resemble adrenal chromaffin cells and have dense core granules containing catecholamines. • Hypoxia causes opening of oxygen sensitive potassium channels that results in potassium efflux and depolarization. Depolarisation results in calcium influx which triggers action potentials. • Cells excited by hypoxia and transmit to afferent nerve via dopamine receptors. Afferent fibres ascend via **glossopharyngeal and vagal nerves**. Type II cells Surround type I cells, function unclear.	How do they work?	

	Pulmonary stretch receptors: Located within smooth muscle of the airways. Hering-breuer reflex – increased respiratory time therefore slowing of respiratory frequency. *Probably not important in humans*		
	Stretch receptors in muscles, joints: Impulses from moving limbs may stimulate ventilation. Also muscle spindles in muscles of respiration.		
	Irritant receptors in lungs, nose & airways: • ***Lungs:*** Located between airway epithelial cells. Stimulated by noxious gas, smoke, dust, cold air. Stimulate bronchoconstriction and increased respiratory rate. • ***Nose and airways:*** Respond to mechanical and chemical stimulation. May result in coughing, sneezing, bronchoconstriction and laryngeal spasm.		
	J receptors respond to engorged capillaries. Located in alveolar walls (juxta capillary) Stimulation results in rapid shallow breathing.		
	Other receptors • ***Arterial baroreceptors*** Increase in blood pressure can cause reflex hypoventilation through stimulation of aortic and carotid sinus baroreceptors. • ***Pain and temperature***		

COMMENTS

Ventilatory response to oxygen lack

- In normal individuals increased efferent output does not result in increased respiratory rate
- Hypoxia causes a relative decrease in hydrogen concentration of arterial blood that results in decreased stimulation of medullary chemoreceptors and inhibition of respiration. Any increase in ventilation that does occur results in reduced pCO_2 and negative feedback via medullary chemoreceptors.
- Hypoxia results in increased sensitivity of medullary chemoreceptors.

TOPIC: Sensors in control of ventilation_______________ **NUMBER:** ___________

OPENING QUESTION	What sensors are involved in control of ventilation?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 Chemoreceptors and mechanical receptors	What senses changes in blood gases?	
	2 Central chemo in medulla respond to H^+		Need peripheral and central
	3 Peripheral chemo in carotid and aortic bodies respond to O2, CO2, H^+		
	4 Stretch receptors in lungs, muscles, joints		
	5 Irritant receptors in airways		
	6 J receptors respond to engorged capillaries		