Physiology week 9 - Cardiovascular (flow/BP) VIVAs

3.2 Flow, pressure, resistance, blood flow	What factors cause turbulence in blood flow?	'Critical velocity'; smaller diameter, reduced viscosity.
	Why is blood flow slower in capillaries?	Velocity relates to total cross sectional area => capillaries, 1000x area aorta, low velocity same flow.
	What is the relationship between pressure and wall tension in blood vessels of different sizes;	P = T/r. Smaller = less tension in the wall for the same distending pressure. Eg aorta : vena cava : capillaries = 170,000 : 21,000 : 16 dynes/cm. Small vessels unlikely to rupture.
	What is the relationship between pressure and wall tension in the heart?	Ventricular dilation means more tension required to generate same pressure = more work.

TOPIC: Factors controlling cardiac output _____ NUMBER: _____ 4a

OPENING QUESTION	What are the parameters that define cardiac output?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 HR x Stroke Vol	1	must pass
SECOND QUESTION	What factors influence stroke volume?		
POINTS REQUIRED	1 afterload	1	3 to pass
	2 preload	2	
	3 contractility	3	
THIRD QUESTION (if needed)	What are the factors that influence contractility?		
POINTS REQUIRED	1 Hypoxia	1	4 of 6 to pass
	2 Drugs +ve / -ve inotropes	2	
	3 pH	3	
	4 sympathetic tone	4	
	5 hypercapnoea	5	
	6 myocardial damage	6	

TOPIC: Factors Affecting CVP_____ NUMBER: _____ 4c

OPENING QUESTION	What is the normal Central Venous pressure at rest	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 = Pressure in Right Atrium = 0 (range −5 to +5)	1	Must pass
		2	
SECOND QUESTION	Describe the factors that determine Central Venous Pressure		
POINTS REQUIRED	1 Balance between venous return, and ability of heart to pump out of RA	1	Must pass
	2 Factors affecting venous return: Gravity, intraabdominal pressure (eg pregnancy), hypo/hypervolaemia, venodilation (drugs/fainting), sympathetic tone (vasoconstriction), arteriodilation (sepsis, drugs, anaphylaxis), resistance to venous return (tamponade, tumour)	2	2 examples to pass
	3 Factors affecting ability of heart to pump blood: Myocardial contractility, Hypertrophy (Athlete) Cardiac Failure, Myocardial Infarction (RV), Arrhythmias, Atrial Fibrillation (Volume & filling time, and contractility). Resistance to RV = Pulm valve stenosis, PE, LVF, Hypoxia, tension PTx	3	2 examples to pass

1.3 Pressure, flow & resistance (Guyton pp 164-170)	What are the basic factors which determine the rate of flow of blood through a blood vessel?	Poiseulle's Law and formula describe these factors; **(Radius to 4th power + 2 others)** Where: F is the rate of flow; $P_A - P_B$ is the pressure differential; $F = \frac{P_A - P_B}{R}$ R is the resistance: r is the radius of the tube; $R = \frac{8 \eta L}{\pi r^4}$ η is the viscosity of the fluid L is the length of the tube $F = P_A - P_B \times \frac{\pi r^4}{8 \eta L}$	
	What factors cause turbulent flow in a blood vessel?	Expressed by Reynold's number; **(3 out of 4)** Where: ρ is the fluid density; D is the diameter of the tube; $Re = \frac{\rho D V}{\eta}$ V is the velocity of flow; η is the viscosity of the fluid. The higher the value of Reynold's number the greater the probability of turbulence' which usually occurs when Reynold's number is between 2000-3000.	

TOPIC: Hormonal factors affecting arteriolar tone_____ **NUMBER:** _____ 2b

OPENING QUESTION	Discuss the hormones that influence arteriolar tone	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1. Adrenaline is released from the adrenal medulla in response to sympathetic stimulation. It acts via alpha-1 receptors to constrict arterioles in most areas. It also acts via Beta 2 receptors to vasodilate muscle and liver blood vessels.	1	
	2. Noradrenaline although largely a neurotransmitter, is released from the adrenal medulla in response to sympathetic stimulation. It acts via alpha 1 receptors to constrict arterioles.	2	
	3. Angiotensin II is a generalised arteriolar constrictor. It is formed from angiotensin I in the lung.	3	1,2 and 2 others to pass
	4. Vasopressin is a potent arteriolar constrictor. It is released from the posterior pituitary.	4	
	5. Bradykinin is a tissue hormone that causes arteriolar dilatation.	5	
	6. Histamine is produced by basophils and mast cells and causes arteriolar dilation.		
	7. Serotonin ??		
	8. Adrenomedullin ??		

TOPIC: Neural factors affecting arteriolar tone _____ **NUMBER:** _____ 2a

OPENING QUESTION	Discuss the central neural control affecting arteriolar tone	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1. Presence of a vasomotor centre situated in the CNS medulla with both vasoconstrictor and vasodilatory areas	1	3 of 5 to pass
	2. Medullary vasomotor centre is influenced by peripheral baroreceptors, peripheral chemoreceptors and higher neural centres	2	
	3. Noradrenergic vasoconstrictor fibres descend from medullary vasomotor centre via spinal cord to the smooth muscle in the walls of arterioles	3	
	4. Peripheral baroreceptors in carotid sinus and aortic arch respond largely to changing blood pressure and act to inhibit vasoconstrictor centre	4 what are the inputs?	
	5. Peripheral chemoreceptors in carotid bodies and aortic bodies respond to hypoxia and act to excite the vasoconstrictor centre	5	
SECOND QUESTION (if needed)	Describe the Volume (atrial stretch) reflex		
POINTS REQUIRED	1. Atrial stretch results in reflex afferent arteriolar renal dilatation		
THIRD			

TOPIC: Local factors affecting arteriolar tone _____ **NUMBER:** _____ 2c

OPENING QUESTION	Discuss the local factors that affect arteriolar tone	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	Arteriolar tone changes to regulate local blood flow across a range of blood pressures. Two theories by which this occurs: myogenic or metabolic.	1	2 theories to pass
	Myogenic theory – distension of vessel with increasing pressure stretches the vascular smooth muscle leading to contraction of the muscle	2	
	Metabolic theory – vasodilator metabolites accumulate in tissues when blood flow falls leading to relaxation of vascular smooth muscle.	3	
	Vasodilators include local hypoxia and acidosis, CO2 build up, heat, potassium, lactate, histamine, adenosine	4	
	Serotonin causes localised vasoconstriction after vessel injury.	5	
	Prostacyclin (vasodilatation) and thromboxane (vasoconstriction) after local vessel injury		
	Endothelium Derived Relaxing Factor (nitric oxide) Many vasodilators act by activating EDRF		
	Endothelin - vasoconstrictor		

TOPIC: Endothelium and regulation of blood flow _____ **NUMBER:** _____

OPENING QUESTION	Describe how blood flow is regulated at the level of the endothelium	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 Vasodilators: prostacyclins, **NO**, kinins	1 Tell me about local vasodilators.	
	2 Vasoconstrictors: **endothelin**, **thromboxane**, serotonin	2 Tell me about local vasoconstrictors.	
	3	3	
	4	4	
	5	5	
	6	6	
SECOND QUESTION (if needed)	7 What other general effects do endothelins have on the cardiovascular system?	7	
POINTS REQUIRED	1 Positive inotrope and chronotrope	1 Tell me about the effects on the heart and blood pressure	
	2 Rise in ANP/renin/aldosterone	2 Tell me about the renal effects	
	3 Decreased GFR and renal blood flow	3	

TOPIC: Baroreceptors and arterial blood pressure _____ **NUMBER**

OPENING QUESTION	What changes in arterial blood pressure do baroreceptors respond to?	**PROMPTS**
POINTS REQUIRED	1 Carotid sinus (rise or **fall**)	1 Where?
	2 Aortic arch (rise)	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	
SECOND QUESTION (if needed)	What happens when the baroreceptors detect a fall in arterial pressure?	
POINTS REQUIRED	1 Dec firing rate of Hering's nerve	1 Sequence?
	2 CN IX transmits to vasomotor centre	2
	3 Dec parasympathetic outflow to heart	3
	4 Inc sympathetic outflow to heart	4
	5 Inc sympathetic outflow to vessels	5
	6 Inc heart rate, contractility	6
	7 Arteriolar and venous constriction	
THIRD QUESTION (if needed)	What is the Set Point?	
POINTS REQUIRED	1 Neutral MAP for vasomotor centre Around 100 mm Hg	1
	2	2
	3	3
	4	4

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	What is the relationship between pressure and wall tension in blood vessels of different sizes;	P = T/r. Smaller = less tension in the wall for the same distending pressure. Eg aorta : vena cava : capillaries = 170,000 : 21,000 : 16 dynes/cm. Small vessels unlikely to rupture.
	What is the relationship between pressure and wall tension in the heart?	Ventricular dilation means more tension required to generate same pressure = more work.

TOPIC: Hormonal factors affecting arteriolar tone_____ **NUMBER:** _____ 2b

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	2. Noradrenaline although largely a neurotransmitter, is released from the adrenal medulla in response to sympathetic stimulation. It acts via alpha 1 receptors to constrict arterioles.	2	
	3. Angiotensin II is a generalised arteriolar constrictor. It is formed from angiotensin I in the lung.	3	1,2 and 2 others to pass
	4. Vasopressin is a potent arteriolar constrictor. It is released from the posterior pituitary.	4	
	5. Bradykinin is a tissue hormone that causes arteriolar dilatation.	5	
	6. Histamine is produced by basophils and mast cells and causes arteriolar dilation.		
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TOPIC: Local factors affecting arteriolar tone _____ **NUMBER:** _____ 2c

OPENING QUESTION	Discuss the local factors that affect arteriolar tone	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	Arteriolar tone changes to regulate local blood flow across a range of blood pressures. Two theories by which this occurs: myogenic or metabolic.	1	2 theories to pass
	Myogenic theory – distension of vessel with increasing pressure stretches the vascular smooth muscle leading to contraction of the muscle	2	
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	Vasodilators include local hypoxia and acidosis, CO2 build up, heat, potassium, lactate, histamine, adenosine	4	
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	Prostacyclin (vasodilatation) and thromboxane (vasoconstriction) after local vessel injury		
	Endothelium Derived Relaxing Factor (nitric oxide) Many vasodilators act by activating EDRF		
	Endothelin - vasoconstrictor		

TOPIC: Systemic regulation of BP by Nervous system __ NUMBER:

OPENING QUESTION	**Where are Baroreceptors found in the body?**	**COMMENTS**
POINTS REQUIRED	1. **Stretch receptors in adventitia of vessel walls**, major ones found in **carotid sinus and aortic arch** to monitor arterial side of circulation.	
	2. Also "cardiopulmonary receptors" in right and left atria, and pulmonary circulation to monitor venous circulation	Both carotid sinus and aortic arch to pass
PROMPTS	Which blood vessels contain baroreceptors?	
SECOND QUESTION (if needed)	**What is the effect of vessel wall distension on a baroreceptor?**	
POINTS REQUIRED	**Stretch of vessel wall leads to increased baroreceptor discharge**, transmitted by afferents in glossopharyngeal and vagus nerves to **medulla. (vasomotor centre)** This results in release of inhibitory GABA which reduces sympathetic outflow, and excitatory effects on vagal motor neurones. Net effect is: **1. Inhibition of tonic discharge of vasoconstrictor nerves** **2. Excitation of cardiac vagal innervation** **Results in vasodilation, with decrease in BP, HR and CO.**	Bolded
PROMPTS	How does the baroreceptor respond to an increase in BP?	

TOPIC: Venous return curve / mean systemic filling pressure **NUMBER:** _____

OPENING QUESTION	What is the normal value for venous return in the healthy human adult?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 5-5.5 l/min		
SECOND QUESTION	What are the major factors that influence venous return to the heart?		¾ to pass
POINTS REQUIRED	1 Circulating blood volume		
	2 Sympathetic and parasympathetic tone		
	3 Muscle pump		
	4 Right atrial pressure (intrathoracic and intracardiac pressures and factors that influence them like phases of respiration, tamponade, PEEP		
THIRD QUESTION	What is the relationship between right atrial pressure and venous return?	What happens to venous return when right atrial pressure rises?	
POINTS REQUIRED	1 Downslope - reduced driving pressure	Please graph this if it helps.	
	2 Plateau – collapse of vein walls		
	3 Normal value for MSPF = 7 mmHg		
	4 Normal value for mean RAP = 0 mmHg		

TOPIC: Arterial pressure regulation _____ **NUMBER:** _____

OPENING QUESTION	What are the major factors affecting the regulation of arterial pressure?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	1 Seconds/minutes: baroreceptors, chemoreceptors, CNS ischaemic receptors	What systems enable responses to changes in arterial pressure for example with acute haemorrhage? Describe the baroreceptor reflex.	Must describe baroreceptors and angiotensin to pass.
	2 Minutes/hours: stress (stretch) relaxation, renin-angiotensin vasoconstriction, blood volume change and fluid shift through capillaries		
	3 Longer term: renal compensation via aldosterone, blood volume changes, salt intake	What happens in the longer-term?	

TOPIC: Cardiac Function_____

OPENING QUESTION	**What are the determinants of myocardial oxygen consumption?**	COMMENTS
POINTS	Heart rate	2/3
	Wall tension	
	Myocardial contractility	
PROMPTS		
SECOND QUESTION	**What are the changes in cardiac function with exercise and how these mediated?**	
POINTS	Rate and stroke volume	2/3
	Adrenaline and sympathetic discharge	
	Venous return	
PROMPTS		
THIRD QUESTION	**What are the physical laws involved?**	
POINTS	Starling	1/2
	La Place P =2T/R	
PROMPTS		

1.3 Pressure, flow & resistance (Guyton pp 164-170)	What are the basic factors which determine the rate of flow of blood through a blood vessel?	Poiseulle's Law and formula describe these factors; **(Radius to 4th power + 2 others)** Where: F is the rate of flow; $P_A - P_B$ is the pressure differential; R is the resistance: r is the radius of the tube; η is the viscosity of the fluid L is the length of the tube $F = \frac{P_A - P_B}{R}$ $R = \frac{8 \eta L}{\pi r^4}$ $F = P_A - P_B \times \frac{\pi r^4}{8 \eta L}$
	What factors cause turbulent flow in a blood vessel?	Expressed by Reynold's number; **(3 out of 4)** Where: ρ is the fluid density; D is the diameter of the tube; V is the velocity of flow; η is the viscosity of the fluid. $Re = \frac{\rho D V}{\eta}$ The higher the value of Reynold's number the greater the probability of turbulence' which usually occurs when Reynold's number is between 2000-3000.
2.3 Factors controlling cardiac output & O_2 consumption Ganong pp 571-576	What factors control cardiac output?	**Cardiac Output = Heart Rate x Stroke Volume** **Heart rate** controlled by cardiac innervation – symp. / parasymp. **Stroke Volume:** • **Afterload** • **Preload** - Starling Curve (Fibre length-tension) **(2 out of 5):** Pericardial pressure; Ventricular compliance; Atrial filling; Blood volume; Intrathoracic pressure • **Contractile state (3 out of 7):** Cardiac innervations; Hypoxia; hypercapnia; acidosis; Drugs +ve & -ve inotropes Circulating catecholamines; Loss of myocardium; Intrinsic depression (Heart failure) Force-frequency relationship
	What are the major factors which determine myocardial oxygen consumption?	**(2 out of 3)** Intramyocardial tension Contractile state of myocardium Heart rate (= Ventricular work/beat = SV x MAP)

TOPIC: Arterial pressure regulation_____ **NUMBER:** _____

OPENING QUESTION	What are the major factors affecting the regulation of arterial pressure?	**PROMPTS**	**COMMENTS**
POINTS REQUIRED	**There are several ways to classify. Here's one…**		
	A. Seconds/minutes: sympathetic nervous system activation & parasympathetic NS suppression 1. Baroreceptors- Stretch receptors in walls of heart and blood vessels. • Carotid sinus (just above bifurcation of common carotid) • Aortic arch Stimulated by distension of the structure causing increased rate of discharge. 2. Afferents pass via glossopharyngeal and vagus nerves (the 'buffer nerves'- thanks Ziad). 3. Afferents end on the nucleus of the tractus solitarius (in the medulla) resulting in glutamate transmission. 4. Project to the RVLM and stimulates GABA inhibitory neurons. **I.E. ↓BP → less distension → fewer inhib neurons fire → auton NS causes vasoC, incr HR & force** Also **low pressure receptors in atria and pulmonary arteries.** Effective in control of sudden volume change Stretch causes Reflex dilatation of afferent arterioles in the kidney → Decreased vasopressin/ADH secretion by the hypothalamus Release of ANP Tachycardia (direct effect) Tachycardia (Bainbridge reflex) Also **chemoreceptors**- Play a secondary role in BP control – more active in respiratory control Also **CNS ischaemic receptors**: BP below 60mmHg stimulates intense sympathetic vasoconstriction: 'last-ditch' attempt to maintain arterial pressure	1. What systems enable responses to changes in arterial pressure for example with **acute haemorrhage?** (i.e. this is not about autoregulation) 2. Describe the baroreceptor reflex.	Must describe baroreceptors and angiotensin to pass.
	2 Minutes/hours: • stress (stretch) relaxation • renin-angiotensin vasoconstriction • blood volume change and fluid shift through capillaries		

	Details on Angiotensin II: • Formed from angiotensin I by the action of renin. • Renin secretion at any given time is determined by the summed activity of several factors.: -Angiotensin II feedback -Afferent arteriolar pressure decrease results in increased renin secretion. -Sodium reabsorption across the macula densa decreased absorption causes increased renin secretion. -Stimulation of beta 1 adrenoceptors by circulating catecholamines result in increased renin release. -Increased sympathetic activity via renal nerves. -Prostaglandins (especially prostacyclin) stimulate renin secretion **FX of angiotensin:** • VasoC • ↑ aldosterone secretion (therefore Renal: ↑ Na/ H2O retention) •		
	3 Longer term: renal compensation via aldosterone, blood volume changes, salt intake	What happens in the longer-term?	

TOPIC	QUESTION	ESSENTIAL KNOWLEDGE	NOTES
Question 1: Factors determining myocardial O2 demand Ganong pp 575-76	i) What factors determine myocardial oxygen demand?	i) **1) Heart Rate** **2)Intramyocardial Tension** **3)Contractile state of the myocardium** OR 1) **Stroke Volume** **2) MAP**	Core knowledge in bold. 2 out of 3
	ii) What effect does increase in preload and afterload have on myocardial O2 demand? Prompt: How does it work?	i) **Both increase** Ventricular work per beat correlates to O2 consumption Work = SV x MAP Stroke work LV is 7x that of RV Theoretically, volume changes and pressure changes should affect myocardial O2 consumption equally. HOWEVER, pressure work produces a greater increase in O2 consumption than does volume work. Reason not well understood Net result ; **Changes in afterload have greater effect than changes in preload.** Tension in the wall of a hollow viscus is proportional to the radius of the viscus. Myocardial fibres are stretched with increased stroke volume in a dilated heart. Increased radius of dilated heart increases wall tension which explains the increased oxygen consumption	Core knowledge in bold. Both increase Changes in afterload have greater affect than changes in preload