Exam Key

NROSCI/BIOSC 1070 and MSNBIO 2070
Exam # 2
October 24, 2014

Total POINTS: 100	**20% of grade in class**

1) A soldier is injured on the battlefield, and it is suspected that he has brain edema. The only treatments available to the medic are isotonic, hypertonic, and hypotonic saline.

a) Would intravenous injection of any of these saline solutions aid in reducing brain edema? Provide a brief explanation for your answer ***(5 points).***

Hypertonic solutions increase the osmolarity of the plasma relative to the interstitial space. Consequently, Na+ and Cl- diffuse into the interstital space from capillaries, while there is an increased driving force for water to enter the capillary until the osmolarity in the plasma and interstitial space are balanced. This causes the osmolarity of the interstitial fluid to be higher than the intracellular fluid. Consequently, water leaves the cells and as a result they shrink (intracellular volume decreases).

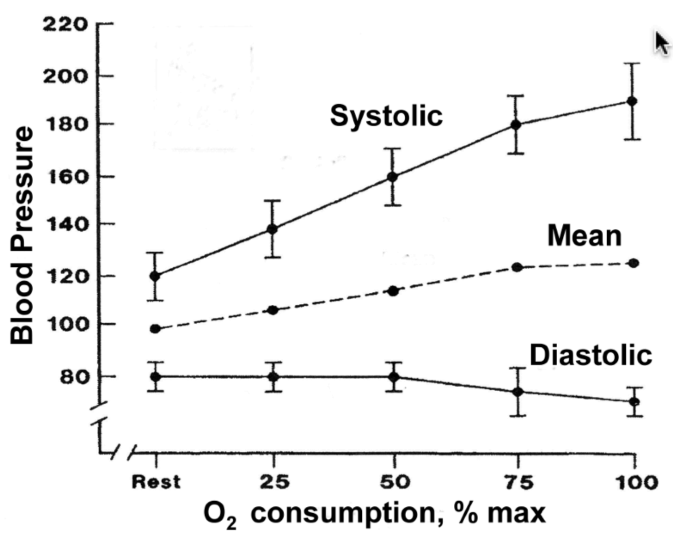
This sequence of events would aid in reducing brain edema.

b) Would intravenous administration of a saline solution to the soldier change his oncotic pressure? Provide a brief explanation of your answer. ***(5 points).***

Providing saline increases the total blood volume, but adds no protein. Hence, the amount of protein per unit volume of blood decreases, This causes a decrease in oncotic pressure.

2) Mean blood pressure increases modestly during exercise, but the increase in systolic and diastolic blood pressure are not proportional. How do systolic and diastolic pressure change during exercise? Provide the physiological rationale why one pressure changes more than the other during exercise. ***(10 points).***

Systolic pressure increases much more than diastolic pressure during exercise. In fact, diastolic pressure can even decrease. Several factors help to explain the disproportional effect of exercise on systolic and diastolic pressure. First, arterial compliance decreases, which promotes the rapid drop in blood pressure during diastole. In addition, the large reduction in total peripheral resistance provides for a rapid runoff of arterial blood into the capillaries, and a large drop in pressure during diastole.



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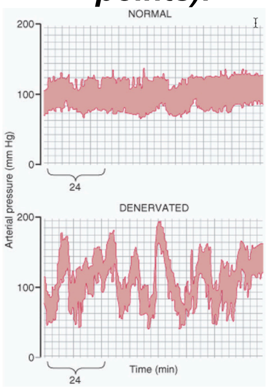
3) What is mean blood pressure over a 48-hour period in an animal a week following the transection of the IX^{th} and X^{th} cranial nerves? What physiological mechanism is responsible for maintaining mean blood pressure at this level? ***(5 points).***

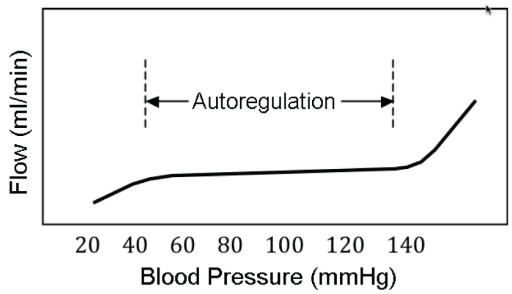


Mean blood pressure is near 100 mm Hg, although there are huge swings above and below this value. Blood pressure is being maintained through the renin-angiotensin system. As blood pressure decreases, renin release increases, and vice-versa. Hormonal systems require much more time than neural systems to elicit a physiological change. Thus, blood pressure is labile, but maintained at the same mean level before and after baroreceptor denervation.

4) Patients with allergies to bee stings can suffer a life-threatening drop in blood pressure following an insect sting. Discuss in detail the physiological mechanisms that result in profound hypotension following bee stings in sensitive individuals. ***(5 points).***

Bee stings can induce anaphylaxis. Antigens (the foreign material that provokes the allergic reaction) cause mast cells to release histamine. Histamine has two effects: it produces vasodilation and causes larger gaps between endothelial cells (increased capillary permeability). As a result, peripheral resistance and blood volume can drop, which results in hypotension.

5) An artery is removed from an experimental animal and the ends are attached to tubing to push fluid through the vessel. The vessel is maintained in a medium with similar ionic concentrations and osmolarity as plasma. How does blood flow through the isolated vessel change as perfusion pressure increases from 90 to 120 mmHg? Briefly describe the physiological basis for your answer. ***(5 points).***



The isolated blood vessel is free from hormone and neural influences, but is still subject to autoregulation. A rise in pressure opens stretch-sensitive sodium channels in smooth muscle cells, thereby resulting in depolarization of the cells. This depolarization elicits an opening of voltage-gated calcium channels, thereby increasing calcium entry into the smooth muscle cells and causing their contraction. Through this mechanism, vasoconstriction occurs in proportion to changes in perfusion pressure, maintaining constant flow through the vessel.

6) A potentially serious side effect in patients taking Angiotensin Converting Enzyme (ACE) inhibitors is hyperkalemia, or too much potassium in the blood. Briefly describe how taking an ACE inhibitor can produce hyperkalemia. ***(5 points).***

Suppression of angiotensin II leads to a decrease in aldosterone levels. Since aldosterone is responsible for increasing the excretion of potassium, ACE inhibitors can cause retention of potassium.

7) A number of physiological changes occur while astronauts reside aboard the International Space Station. Does blood volume in astronauts increase, decrease, or remain the same during a prolonged period in space? Provide a rationale for your answer. ***(10 points).***

Blood volume drops up to 25% during spaceflight. Without gravity, more blood accumulates in the upper body, stimulating baroreceptors. There is also increased right atrial stretch, as gravity does not oppose venous return to the heart. As a result, a number of hormonal changes occur, including a decrease in vasopressin levels, a decrease in angiotensin II levels, a decrease in aldosterone levels, and an increase in atrial natriuretic hormone levels. All of these hormonal changes induce fluid loss from the body.

8) A person quickly drinks 2 liters of water. Describe the effect this will have on GFR. Provide a rationale for your answer. ***(10 points).***

There are two possible approaches to this question, and you will receive credit for either if you accurately articulate the rationale for your answer.

First potential answer:
Drinking 2L of hypotonic water would dilute the plasma significantly. Decreasing plasma osmolarity would decrease delivery of Na to the macula densa. This would result in a constriction of the efferent arterioles (via the renin-angiotensin system) and dilation of the afferent arterioles (via NO). This would increase GFR by increasing hydrostatic pressure.

Oncotic pressure would also decrease because of the dilution of plasma proteins. Thus, the net filtration pressure would increase and thus increase GFR.

Second potential answer:
GFR won't change due to regulatory mechanisms (which you would need to describe).

9) High levels of plasma protein can interfere with filtration across the basal lamina (e.g., picture that the filter at this level gets clogged). What impact would that have on renal function? ***(10 points).***

There would a significant decrease in filtration. The proteins would become stuck in the glomerulus and effectively decrease Kf because the fenestrations in the capillaries would become clogged and plasma would not be filtered. Oncotic pressure would also be very high which would act against hydrostatic pressure and decrease net filtration (i.e. GFR).

10) PAH clearance in a patient is measured at 500 ml/min, which is clearly abnormal.

a) What factors could contribute to this abnormal PAH clearance, and what measurements could you make to determine the cause of this abnormal clearance rate? ***(8 points).***

Renal blood flow must be low, which could be due to low blood pressure (cardiac output) or increased renal artery resistance (either afferent or efferent). To make a distinction, it would be important to measure the patient's blood pressure and cardiac output (using the Fick method).

Question continues on the next page

b) What do you think filtration fraction would be in this patient? Provide a justification for your answer*.* ***(7 points).***

Because Na delivery to the macula densa is lower due to the decrease in renal plasma flow, there would be an increase in GFR because of regulation of the efferent and afferent arterioles. Filtration fraction is GFR/RPF, so an increase in GFR and a drop in renal plasma flow would cause an increase in the filtration fraction.

Alternately, if you argued in **part (a)** that decreased RPF is a due to a problem with afferent arteriolar resistance (not low blood pressure), then GFR would be reduced.

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11) During initial clinical tests of a new drug it was noted that patients urinate more and drink more. Describe the actions of the drug that might result in these physiological effects (describe all the possible mechanisms that have been discussed in class). What tests might you perform to distinguish between the possible actions of the drug? ***(15 points).***

There are two possible mechanisms: the drug is an osmotic diuretic or it reduced ADH secretion and/or blocked ADH receptors.

The primary way to distinguish is by measurement of urinary osmolality and solute excretion, as a way of separating whether it is diuresis resulting from ADH issues or solute issues. If it is an ADH issue, the next step would be distinguishing between central or nephrogenic (e.g., measure ADH levels in blood or effect of a V2 agonist). To distinguish among different classes of osmotic diuretics, the first thing they might do is look at K+ clearance, as this might suggest whether it is related to aldosterone or not. Na+ excretion would start to get at what solute was involved in the osmotic diuresis (e.g., is it Na+ or something else).