



Please note – this learning resource has been produced by the GUMS Academic Team. It is possible that there are some minor errors in the questions/answers, and other possible answers that are not included below. Make sure to check with other resources.

**1. In which of the following scenarios would you expect to see the highest renin activity?**

- A) In a 70yo patient with essential hypertension
- B) In the affected kidney of a patient with renal artery stenosis**
- C) In the unaffected kidney of a patient with renal artery stenosis
- D) In a patient taking an ACE inhibitor

Reduced perfusion from renal artery stenosis causes activation of RAAS system (renin converts angiotensinogen to angiotensin I, ACE converts from ang I to ang II -> vasoconstriction and aldosterone release -> secondary hypertension).

In the other kidney, renin activity will be low due to increased perfusion caused by high blood pressure.

In essential hypertension, the pathophysiology mostly relates to reduced elasticity of blood vessels with aging.

Taking an ACE inhibitor doesn't have much of an impact on renin activity.

**2. Atrial natriuretic peptide is a hormone that is made in the atria of the heart. The influence of this hormone is to:**

- A) Enhance atrial contractions
- B) Activate the renin-angiotensin system
- C) To prevent pH changes caused by organic acid
- D) To reduce blood pressure and blood volume by inhibiting sodium and water retention**

Note for tutors: this is a good time to mention BNP and its usefulness in diagnosing fluid overload in CCF

BNP is released from the heart (particularly ventricles) in response to increased stretch within the atria and ventricles.

Has diuretic, natriuretic and hypotensive effects by inhibiting the RAAS system, endothelin (vasoconstriction) and systemic sympathetic activity. Therefore decreasing vasoconstriction and Na retention.

BNP can rapidly increase in patients with heart failure and can be useful diagnostically for;

- Diagnosis for patients with dyspnoea for Heart failure
- Prognosis of heart failure



**3. Administration of which of the following fluids is likely to increase a patients intravascular volume the most?**

(NB: this question is probably a bit beyond ISM so don't stress if you don't get it. Also feel free to look up what the numbers means in terms of osmolarity)

- A) 2L of 0.9% NaCl (normal saline)
- B) 1.5L of 5% dextrose
- C) 1L of 4% albumin
- D) 1L of 5% dextrose.
- E) 1L of 5% dextrose in 0.9% NaCl

Na<sup>+</sup> is the major extracellular cation, normal saline distributes throughout the extracellular compartment (intravascular and interstitial spaces). Since the extracellular fluid compartment is mostly made up of the interstitial space, most of the fluid given (approx.  $\frac{3}{4}$ ) actually ends up in the interstitial space. Therefore, by giving 2L of normal saline, you are only increasing the intravascular volume by about 500mL.

Albumin is the main constituent of serum protein. As a protein, it cannot cross cell membranes and therefore it stays almost entirely in the intravascular compartment. Therefore, 1 litre of 4% albumin will increase by almost 1 litre.

As for the 5% dextrose in 0.9% NaCl, the dextrose (a sugar) will rapidly be taken up by cells and also metabolized. Therefore this solution effectively becomes 0.9% NaCl and has a similar effect to the one described above. Giving 5% dextrose on its own is effectively giving a hypotonic solution because the dextrose is taken up/metabolised, leaving behind a bunch of water. Therefore, the water that's left behind will distribute by osmosis across both intracellular and extracellular fluid compartments.

**4. In which of the following patients would you expect to see the lowest serum concentration of Na<sup>+</sup>?**

- A. A patient with diabetic insipidus
- B. A patient with syndrome of inappropriate ADH secretion (SIADH)
- C. A patient who's just received 1 litre 0.9% NaCl of fluid resuscitation for dehydration
- D. A patient with primary hyperaldosteronism (Conn's syndrome)



Diabetes insipidus is a condition where the kidneys are unable to concentrate urine as normal via anti-diuretic hormone (either because of insufficient levels of ADH made by pituitary or defective ADH receptors). Therefore, patients with diabetes insipidus are likely to have hypernatraemia.

Syndrome of inappropriate ADH secretion is essentially the opposite scenario where there is excess ADH secretion -> excess water reabsorption -> hyponatraemia

**5. List 4 signs of dehydration on physical examination**

- Reduced skin turgor
- Postural hypotension
- Tachycardia
- Dry mucous membranes (ask patient to poke their tongue out)
- Sunken eyes
- Reduced urine output and dark, concentrated urine

**6. A patient presents to an emergency department with vomiting and diarrhoea of several days duration. Their vital signs and laboratory findings are as follows:**

<b>Body weight</b>	<b>62kg</b>
<b>Height</b>	<b>165cm</b>
<b>Temperature</b>	<b>37.2 (normal 36.8-37.5)</b>
<b>Heart Rate</b>	<b>112 beats per minute (normal 60-100)</b>
<b>Blood Pressure</b>	<b>115/70 mmHg lying down, but is 95/55 when standing (normal 100/60 – 140/90, with no difference between lying and standing)</b>

<b>FBC (full blood count)</b>	<b>Reference Range Female Adult</b>
<b>Haemoglobin (Hb) 174g/L</b>	<b>115-165 g/L</b>
<b>White Cell Count (WCC) <math>10.5 \times 10^9</math> cells/L</b>	<b>4-11 <math>\times 10^9</math> cells/L</b>
<b>Platelets <math>250 \times 10^9</math> cells/L</b>	<b>150-400 <math>\times 10^9</math> cells/L</b>

<b>Urea and Electrolytes</b>	<b>Reference Range</b>
<b>Sodium (Na) 141 mmol/L</b>	<b>135-145 mmol/L</b>
<b>Chloride (Cl-) 109 mmol/L</b>	<b>95-110 mmol/L</b>
<b>Urea 19 mmol/L</b>	<b>3.0-8.0 mmol/L</b>
<b>Creatinine 111 <math>\mu</math>mol/L</b>	<b>45-90 <math>\mu</math>mol/L</b>
<b>Osmolality 313 mmol/kg</b>	<b>275-295 mmol/kg</b>



**a) Why is there a drop in blood pressure from lying to standing?**

In this case, this is because of hypovolaemia. When a healthy person goes from lying to standing, there is some pooling of blood in the lower extremities, this decreases venous return, CO and therefore blood pressure. The fall in blood pressure is detected and the baroreceptor reflex kicks in to increase sympathetic outflow -> increasing peripheral resistance, venous return and cardiac output. Because of the baroreceptor reflex, the postural drop should be no more than 5-10mmHg.

In a dehydrated person, there is already a high degree of vasoconstriction to maintain BP at what it is. The baroreceptor reflex initiated by low BP is ineffective because of low blood volume -> low venous return -> low CO. And therefore the blood pressure drops significantly from lying to standing.

**b) Why are the urea and creatinine elevated?**

The kidneys must be perfused in order to work effectively. Low blood pressure from low blood volume results in low glomerular filtration rate and consequently things like urea and creatinine which are normally filtered out by the kidney are retained. This is called a prerenal acute kidney injury.

**c) Why is haemoglobin elevated?**

It appears elevated because the volume of serum has decreased due to dehydration. The absolute amount of haemoglobin has not increased.

**d) Describe the changes in intravascular and intracellular volumes should an Isotonic, Hypotonic and Hypertonic solution be given (at different times of course)**

Giving an Isotonic solution will cause an equal distribution of fluid between the intravascular and intracellular spaces.

A Hypotonic solution will cause the majority of the fluid to move out of the intravascular space and into the intracellular spaces, due to the movement of water from high concentration (intravascular) to low concentration (intracellular).

A Hypertonic solution will cause the majority of fluid to move out of the intracellular space and into the intravascular space due to osmosis but in the opposite direction to the hypotonic solution.

**A severely dehydrated patient enters the ward around the same time, you are asked by your consultant whilst she is saving their life, some very confusing questions.**

**a) Discuss THREE key homeostatic/physiological mechanisms that are triggered by the dehydration**



able to give more than this but something along the lines

1. Baroreceptor reflex, due to loss of vessel stretch, this leads to decreased firing from the baroreceptors (found in every major arterial vessel, however the aortic arch and carotid body are main ones) leading to loss of the inhibition of the sympathetic drive within cardiovascular centre of the medulla)
2. RAAS activation (go through RAAS if students unfamiliar), both from the baroreceptor reflex causing sympathetic activation and from the low Na detection via the macula densa cells within the Juxtaglomerular apparatus.
3. ADH secretion from the hypothalamus via the posterior pituitary due to osmoreceptors present in the hypothalamus and RAAS activation

**b) Describe the likely changes in MAP and cardiac output of this patient and how the homeostatic mechanisms previously discussed attempt to correct this.**

MAP = mean arterial blood pressure -> pressure that propels the blood towards the tissues

**Theoretical calculation (based on pure physiology)**

$$\text{MAP} = \text{CO} \times \text{TPR}$$

**Actual MAP calculation (what is important on the ward)**

$$\text{MAP} = \text{diastolic pressure} + (\text{pulse pressure}/3)$$

OR

$$\text{MAP} = \frac{2}{3} \text{ diastolic} + \frac{1}{3} \text{ systolic}$$

**NOTE:**

TPR = total peripheral resistance -> resistance opposing blood flow in the peripheries

$$\text{CO} = \text{SV} \times \text{HR}$$

The patient will have a decreased SV from the loss of fluid in the intravascular space -> decreased preload + reduction in SV -> decrease CO -> decreased MAP

The homeostatic mechanisms previously discussed work in five main ways,

1. Low MAP -> Baroreceptor reflex -> Increased sympathetic tone -> Increased heart rate -> increase CO -> Increased MAP
2. Low MAP -> Baroreceptor reflex -> Increased sympathetic tone -> vasoconstriction of peripheral vessels -> Increase TPR -> increasesde MAP
3. Decreased MAP -> Low kidney perfusion -> activation of RAAS -> ADH and Aldosterone secretion -> Increased water retention from the kidneys -> increased preload -> increased SV -> increased CO -> increased MAP



4. Low kidney perfusion -> RAAS activation -> Ang II formation -> Activation of the thirst centre in hypothalamus -> increased thirst and water intake -> increased SV -> increased CO -> increased MAP

5. Low kidney perfusion -> RAAS activation -> Ang II formation -> increased peripheral vasoconstriction -> increased TPR -> increased MAP

NOTE:

ADH works at collecting duct on aquaporin channels to cause the reabsorption of water

Aldosterone works at the distal convoluted tubule to reabsorb Na and water

**c) Would the patients blood osmolarity likely be hypertonic/hypotonic/isotonic? What about their intracellular osmolarity?**

The patient's blood osmolarity is most likely to be hypertonic -> due to the loss of water -> increase in electrolyte concentration.

Intracellularly, if the dehydration is acute, there is little to no change, however if more chronic (hours to days), there will be movement of water from the intracellular space into the intravascular -> slightly hypertonic intracellular fluid

Mechanism:

Chronic hypertonic blood osmolarity -> Increased blood electrolyte concentration -> Increased osmotic pull from intracellular space -> loss of intracellular fluid -> increased intracellular electrolyte concentration -> hypertonic intracellular fluid

NOTE:

In the acute stage of hypertonic blood osmolarity, fluid moves from the intercellular space -> blood

**Please provide feedback for this case at:**

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