Fluid and Electrolytes
Questions and Answers

Based on Lecture Notes on General Surgery, 10th edition by Calne, Ellis and Watson, with kind permission of Blackwell Publishing.

Questions

001. In the normal person, what proportion of the total body weight is water?

002. What percentage of the bodyweight of a normal person is intracellular fluid?

003. What percentage of the bodyweight of a normal person is extracellular fluid?

004. What percentage of the extracellular volume in a normal person is intravascular?

005. What percentage of the extracellular volume in a normal person is extravascular or interstitial?

006. What makes up the extracellular compartment?

007. How can fluid cross between fluid compartments? What does this depend on?

008. Is the electrolyte composition of each fluid compartment the same?

009. How does the electrolyte composition of the intracellular fluid compartment differ from the electrolyte composition of the extracellular fluid compartment in terms of potassium and sodium?

010. What percentage of the total body's potassium is in the extracellular fluid?

011. How does the protein concentration differ between the extracellular compartments?

012. If you want to fill the intravascular compartment, what would be your choice of fluid?

013. If you gave a litre of saline, how much would you expect to stay in the intravascular compartment?

014. Which fluid would you use if you wanted it to redistribute across the intracellular and extracellular compartment?

015. How can you calculate daily fluid and electrolyte requirements?

016. How is fluid lost from the body?

017. What are insensible fluid losses?

018. How are fluid losses from the kidney regulated in the absence of intrinsic renal disease?

019. Why are Aldosterone and antidiuretic hormone so important?
020. What does Aldosterone do?

021. What does ADH do?

022. What are the normal urinary losses from the kidney per day?

023. What is the role of the kidneys in normal fluid losses?

024. How is fluid lost to the gastrointestinal tract? What is the normal amount of fluid lost per day in the faeces?

025. How is fluid lost by insensible losses? What is the normal loss of fluid by this route?

026. Which abnormalities of fluid loss by the kidney can occur?

027. What are the main abnormal causes of increased losses of fluid from the kidney?

028. What are the main abnormal causes of water retention and haemodilution?

029. What abnormalities in the gut can cause an increase in water loss via this route?

030. What marks the resolution of a paralytic ileus and why?

031. What are the main abnormal insensible water losses?

032. What are the normal losses of sodium ions from the body per day?

033. What are the effects of surgery on body fluids? Why?

034. How would you replace normal losses of fluids?

035. What are special fluid losses? How would you replace them?

036. What is the normal daily fluid loss by the body? What are the components of this?

037. What is the normal daily loss of potassium from the body?

038. What are the normal plasma values of sodium, chloride, potassium, bicarbonate and calcium?

039. What are the values of sodium, chloride, potassium, bicarbonate and calcium in Hartmann's (compound sodium lactate)?

040. What are the values of sodium, chloride, potassium, bicarbonate and calcium in Normal saline (0.9% saline)?

041. What are the values of sodium, chloride, potassium, bicarbonate and calcium in 4% dextrose or 0.18% saline?

042. How much gastric fluid is there in the human body?

043. What are the concentrations of sodium, potassium, chloride and hydrogen ion/or bicarbonate ion in Gastric fluid?

044. How much bile fluid is there in the human body?
045. What are the concentrations of sodium, potassium, chloride and hydrogen ion/or bicarbonate ion in bile fluid?

046. How much pancreatic fluid is there in the human body?

047. What are the concentrations of sodium, potassium, chloride and hydrogen ion/or bicarbonate ion in pancreatic fluid?

048. How much small bowel fluid is there in the human body?

049. What are the concentrations of sodium, potassium, chloride and hydrogen ion/or bicarbonate ion in small bowel fluid?

050. How can you detect the clinical signs of dehydration? What is their significance?

051. What would you give a patient of 70kg presenting with a perforated peptic ulcer if on examination he is noted to have dry mucous membranes, a tachycardia and slight postural fall in arterial blood pressure? Assume the estimated loss of total body water is 10%

052. What is the general rule of thumb when giving intravenous fluids?

053. What is the best guide to the success of fluid replacement?

054. Which measurement can give you a good guide as to the rate of fluid replacement needed?

055. Which specific groups of patients may need to be adequately nourished before and after surgery, in order to improve their outcome?

056. Why is important to have good nutritional status before surgery?

057. What is enteral feeding? Who would you give it to? What does it consist of? What are the complications?

058. Why might you need to use parenteral feeding?

059. How is parenteral feeding administered? Why?

060. What is the principle of parenteral feeding? What does it contain?

061. What are the useful guides as to how much parenteral feeding is required?

062. What does the ability of a patient to benefit from intravenous feeding depend on?

063. How long should parenteral feeding be continued following surgery?

064. How will nurses be aware of a patient’s positive nitrogen balance?

065. Can parenteral feeding be given on a long-term basis?

066. What are the complications of parenteral feeding?

067. How is sepsis from TPN minimised?
68. What is a major cause of morbidity in patients requiring long-term TPN?

69. Would you give insulin to someone on TPN who developed pancreatitis?

**Fluid and Electrolytes: Answers**

001. 60%

002. 40%

003. 20%

004. 5%

005. 15%

006. Intravascular or extravascular (interstitial).

007. Fluid can cross compartments by osmosis, which depends on a solute gradient, and filtration, which is a result of a hydrostatic pressure gradient.

008. No, it is different.

009. Intracellular fluid has a low sodium and a high potassium concentration. In contrast, extracellular fluid (intravascular and interstitial) has a high sodium and low potassium concentration.

010. 2%

011. There is a very low protein concentration in the interstitial compartment but there is a high protein concentration in the intravascular compartment.

012. In order to fill the intravascular compartment rapidly, a plasma substitute or blood is the fluid of choice. Such fluids, with high colloid osmotic potential, remain within the intravascular space, in contrast to a saline solution, which rapidly distributes over the entire extravascular compartment, which is four times as large as the intravascular compartment alone.

013. 250 ml because of the extracellular compartment, one quarter is intravascular compartment and three quarters is extravascular (interstitial).

014. Five per cent dextrose, which is water with a small amount of dextrose added to render it isotonic, will redistribute across both intracellular and extracellular spaces.

015. In order to calculate daily fluid and electrolyte requirements, the daily losses should be measured or estimated.

016. Fluid is lost from four routes: the kidney, the gastrointestinal tract, the skin and the respiratory tract.

017. This is fluid lost from the body by the skin or respiratory tract route.
By Aldosterone and antidiuretic hormone (ADH).

These two hormone systems regulate the circulating volume and its osmolarity, and are thus crucial to homeostasis.

Aldosterone responds to a fall in glomerular perfusion by salt retention.

ADH responds to the increased solute concentration by retaining water in the renal tubules.

1500-2000 mL/day.

The kidneys control water and electrolyte balance closely, and can function in spite of extensive renal disease, and abuse from doctors prescribing intravenous fluids. However, damaged kidneys leave the patient exquisitely vulnerable to inappropriate water and electrolyte administration.

The stomach, liver and pancreas secrete a large amount of electrolyte-rich fluid into the gut. After digestion and absorption, the waste material enters the colon, where the remaining water is reabsorbed. Approximately 300 mL is lost into faeces each day.

Inspired air is humidified in its passage to the alveoli, and much of this water is lost with expiration. Fluid is also lost from the skin, and the total of these insensible losses is around 700 mL/day. This may be balanced by insensible production of fluid, with around 300 mL of "metabolic" water being produced endogenously. The net loss via the insensible route is 400 mL/day.

Impaired tubular function may cause increased losses. Resolving acute tubular necrosis, diabetes insipidus and head injury may result in loss of several liters of dilute urine. In contrast, production of inappropriate ADH by tumours (the syndrome of inappropriate ADH, or SIADH) causes water retention and haemodilution.

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Loss of water by the gastrointestinal tract is increased in diarrhoea and in the presence of an ileostomy, where colonic water reabsorption is absent. Vomiting, nasogastric aspiration and fistulous losses result in loss of electrolyte-rich fluid. Disturbance of the acid base balance may also occur if predominantly acid or alkaline fluid is lost, as occurs with pyloric stenosis and with a pancreatic fistula, respectively. Large occult losses occur in paralytic ileus and intestinal obstruction. Several litres of fluid may be sequestrated in the gut contributing to hypovolaemia. Resolution of an ileus is marked by absorption of the fluid and the resultant hypervolaemia produces a diuresis.

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Hyperventilation, as may happen with pain or chest infection, increases respiratory losses. Losses from the skin are increased by pyrexia and sweating, with up to a liter of sweat per hour in extreme cases. Sweat contains a large amount of salt.

ADH is released in response to surgery, conserving water. Hypovolaemia will cause aldosterone secretion and salt retention by the kidney. Potassium is released by damaged tissues, and the potassium level may be further increased by blood transfusion, each unit containing in excess of 20 mmol/L. If renal perfusion is poor, and urine output sparse, this potassium will not be excreted and accumulates, causing life-threatening arrhythmias. This is the basis of the recommendation that supplementary potassium may not be necessary in the first 48 hours following surgery or trauma.

Replacement of lost fluid in a typical adult is achieved by the administration of 3 liters of fluid, which may comprise 1 liter of normal saline (150 mmol NaCl) together with 2 litres of water (as 5% dextrose). Potassium may be added to each litre bag (20 mmol/L) Adjustments to this regimen should be based on regular clinical examination, measurement of losses (e.g. urine output) and regular blood samples for electrolyte determination. For example, if the patient is anuric, 1 L/day of hypertonic dextrose without potassium may suffice, which has the added advantage of reducing catabolism with the breakdown of protein and accumulation of urea. Daily weighing of the patient will give the best estimate of changes in the total amount of body fluid.

Special losses include nasogastric aspirates, losses from fistulae, diarrhoea and stomas, and covert losses such as occur with an ileus. Loss of plasma in burns also. All fluid losses should be measured carefully where possible, and this volume added to the normal daily requirements. The composition of these special losses varies, but as a rough guide replacement with an equal volume of normal saline should suffice. Extra potassium supplements may be required where losses are high, such as in diarrhoea. Analysis of the electrolyte content of fistula drainage may be useful.

The total loss is 2700 mL. This is composed of 2000 mL in urine, 300 mL in Faeces, 400 mL Insensible losses.

140 mmol/L of sodium, 103 mmol/L of chloride, 4.5 mmol/L of potassium, 26 mmol/L of bicarbonate, 2.5 mmol/L of calcium.

131 mmol/L of sodium, 111 mmol/L of chloride, 5 mmol/L of potassium, 29 mmol/L of bicarbonate, 2 mmol/L of calcium.

150 mmol/L of sodium, 150 mmol/L of chloride, nothing else is in it.

30 mmol/L of sodium, 30 mmol/L of chloride, nothing else is in it.

2500 mL.

30-80 mmol/L of sodium, 5-20 mmol/L potassium, 5-20 mmol/L chloride, 40-60 mmol of hydrogen ions.

500 ml.
045. 130 mmol/L of sodium ions, 10 mmol/L of potassium ions, 100 mmol/L of chloride ions, 30-50 mmol/L of bicarbonate ion.

046. 1000 ml.

047. 130 mmol/L of sodium, 10 mmol/L of potassium, 75 mmol/L of chloride ion, 70-110 mmol/L of bicarbonate ion.

048. 5000 ml.

049. 130 mmol/L of sodium, 10 mmol/L of potassium, 90-130 mmol/L of chloride ion, 20-40 mmol/L of bicarbonate ion.

050. Estimation of the fluid deficit in patients is important in order to enable accurate replacement. Dry mucous membranes, loss of skin turgor, tachycardia and postural hypotension, together with a low jugular venous pressure suggest a loss of between 5 and 15% of total body water. Fluid losses of under 5% body water are difficult to detect clinically; over 15% there is marked circulatory collapse.

051. As an example, consider a 70 kg man presenting with a perforated peptic ulcer. On examination he is noted to have dry mucous membranes, a tachycardia and slight postural fall in arterial blood pressure. If the loss is estimated at 10% of the total body water, itself 60% of body weight, the volume deficit is 10% x 60% of 70 kg, or 10% of 42 L = 4.2 L. As this loss is largely isotonic (gastric juices and the peritoneal inflammatory response, infusion of isotonic saline (normal saline) is appropriate. A general rule of thumb is to replace half of the estimated loss quickly, and then to reassess before replacement of the rest. The best guide to success of resuscitation is the resumption of normal urine output; therefore hourly urine output should be measured. Central venous pressure monitoring will help in the adjustment of rate of infusion.

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055. Those with: Chronic intestinal fistulae, malabsorption, chronic liver disease, neoplasia and starvation, and those who have undergone chemo- and radiotherapy. Wherever possible, nutritional support should be instituted before surgery, as postoperative recovery will be much quicker.

056. They have lowered resistance to infection and impaired wound healing.

057. If the gastrointestinal tract is functioning satisfactorily, oral intake can be supplemented a basic diet introduced through a fine nasogastric tube directly into the stomach. The constituents of the diet are designed to be readily absorbable protein, fat and carbohydrate. Such a diet can provide 8400 kj with 70g protein in a volume of 2L. The commonest complication is diarrhoea, which is usually self limiting. If a prolonged postoperative recovery is anticipated, or a large preoperative nutritional deficit needs to be corrected, consideration should be given to insertion of a feeding jejunostomy at the time of surgery. This has the advantage of avoiding a nasogastric tube.
For patients with intestinal fistulae, prolonged ileus or malabsorption, nutrition cannot be supplemented through the gastrointestinal tract and therefore parenteral feeding is necessary.

This is usually administered via a catheter in a central vein because of the high osmolarity of the solutions used; there is a high risk of phlebitis in smaller veins with lower blood flow.

The principle is to provide the patient with protein in the form of amino acids, carbohydrate in the form of glucose, and fat emulsions such as Intralipid. Energy is derived from the carbohydrate and fat (30-50% fat), which must be given when amino acids are given, usually in a ratio of 1000 kJ/g protein nitrogen. Trace elements, such as zinc, magnesium and copper, as well as vitamins such as vitamin B12 and ascorbic acid, and the lipid soluble vitamins A, D, E and K, are usually added to the fluid, which is infused as a 2.5 L volume over 24 hours.

Daily weights as well as biochemical estimations of electrolytes and albumin are useful guides to continued requirements.

The general state of metabolism and residual liver function.

Nutritional support should be continued in the post-operative period until gastrointestinal function returns and the patient is restored to positive nitrogen balance from the perioperative catabolic state.

Restoration of a positive nitrogen balance is often apparent to nurses and doctors as a sudden occurrence, when the patient starts smiling and asks for food.

Occasionally in chronic malnutrition with fistulae or in patients who have lost most of the small bowel, parenteral feeding may be necessary on a long term basis.

Complications of total parenteral nutrition (TPN) include sepsis, thrombosis, hyponatraemia, hyperglycaemia and liver damage.

To minimise sepsis, the central venous catheter is tunnelled with a subcutaneous Dacron cuff at the exit site to reduce the risk of line infection.

Thrombosis may occur on any indwelling venous catheter.

Hyperglycaemia is common, particularly following pancreatitis, and may necessitate infusion of insulin.