Homeostasis part 4: fluid balance

In this article, the last in a four-part series, we explore fluid maintenance with particular reference to disorders of the pituitary gland. Fluid management techniques and related nursing care are also covered.

Body fluids are mainly water and electrolytes, and the three main organs that regulate fluid balance are the brain, the adrenal glands and the kidneys (Tortora and Grabowski, 2002). One-third of the total is circulatory fluid, sometimes known as extracellular fluid (ECF); the remainder is intracellular fluid (ICF) contained within cells (Docherty and McIntyre, 2002; Edwards, 2001). The anatomy and physiology of homeostasis are covered in part one of this series.

Most tissues contain a lot of water (bones and adipose tissue are the two main exceptions). It has many functions, including (Tortora and Grabowski, 2002; Adam and Osborne, 1997):

- Oxygen transport and carbon dioxide regulation in the blood;
- Chemical and bioelectrical distributions within and between cells and tissues;
- Heat, hormone and nutrient distribution around the tissues;
- Carriage of waste products to the appropriate organ for excretion – generally through the liver and renal system.

**Homeostatic control**

When fluid volume decreases, the concentration of sodium in the blood will increase (increased osmolality, the amount of solute per unit volume), which in turn stimulates the hypothalamus (Tortora and Grabowski, 2002). The hypothalamus is an osmoreceptor – a sensory end organ that reacts to changes in osmotic pressure and has an effect on the pituitary gland.

In response, the posterior pituitary gland releases antidiuretic hormone (ADH, sometimes called vasopressin) into the bloodstream, resulting in the kidneys retaining water. This in turn results in more concentrated urine and an increase in water returned to the ECF, thus correcting the volume depletion (Tortora and Grabowski, 2002; Edwards, 2001) (Fig 1). When sodium concentration in the blood decreases the adrenal cortex is stimulated into secreting the...
hormone aldosterone, which instructs the distal nephrons of the kidney to retain more sodium. Normal levels of sodium in the ECF will attract and maintain the optimum amount of water (Tortora and Grabowski, 2002; Edwards, 2001).

ADH release is also influenced in the following circumstances. Sensors detect stretching of the atria of the heart indicating excessive returning volume of ECF (increased venous return). They stop ADH secretion, which leads to increased excretion of water through renal filtration. The aorta and carotid arteries also have receptors that are sensitive to a reduction in blood pressure (related to the pressure in the left ventricle). These receptors trigger ADH release, thus conserving water at the kidneys (Tortora and Grabowski, 2002; Metheny, 1996).

In addition to regulating total volume, the osmolarity of bodily fluids is closely monitored and regulated because variations may cause damage to cellular structure (swelling or shrinking), disrupting normal cellular function (Edwards, 2001; Metheny, 1996). Regulation of ECF osmolarity is achieved by balancing the intake and output of sodium with that of water.

Fluid balance
To attain the correct balance of ECF and ICF a patient must also take in the correct amount of fluid (Docherty and McIntyre, 2002). In addition, ‘electrolyte balance’ is essential, in other words the correct concentration of various ions in the body, namely sodium, potassium and magnesium. If there is too much or too little of any of these electrolytes this can cause problems. For example, cardiac arrhythmias are triggered by low potassium and low magnesium levels (Docherty, 2002; Smith, 2000).

The serum sodium level defined as ‘normal’ is 135–145mg/dl; the normal potassium level is 3.5–4.5mg/dl (Metheny, 1996). These figures may differ slightly according to local policies. The average fluid input per day is 2,500ml (water as food 1,000ml, water as liquid 1,200ml, water from catabolism 300ml) and output is 2,500ml. Daily input and output is summarised in Table 1.

In some cases patients will need fluid and electrolyte replacement therapy, which nurses are responsible for delivering and monitoring. In general crystalloid fluids (for example saline 0.9% solution or Hartmann’s solution) are recommended as they remain in the ECF longer and are isotonic – that is, they match blood tonicity (Docherty and McIntyre, 2002; RCUK, 2000). Colloid solutions are not generally indicated for most patients for ECF replacement (RCUK, 2005; Nolan, 2001; Smith, 2000) because they move easily into the ICF making them less effective and creating other clinical issues (for example pulmonary oedema and hypotension).

Albumin levels are also important in fluid balance, and should be monitored closely. The protein assists in maintaining colloid osmotic pressure in the circulation (approximately 70–80% of osmotic pressure is created by albumin). A reduction in albumin due to loss, for example in sepsis where there is a higher rate of albumin loss into the tissues, may result in hypotension and hypovolaemia (Kokko and Tannen, 1996). Albumin replacement colloidal therapy is indicated for hypoalbuminaemia volume-depleted patients. The greatest effect is in patients with temporary albumin loss, for example trauma, surgery or burns (Kokko and Tannen, 1996).

Nursing care
Other issues that nurses should consider when nursing patients with fluid balance problems include: the accurate measurement and monitoring of IV fluids over a particular 24-hour period, including correct documentation and prescription of fluids and fluid types; being aware of electrolyte levels and the correct administration of replacement elements as prescribed; the accurate measurement of oral fluid input and urine output, working in partnership with the patient where possible.

Daily morning weights are useful to establish a trend in overall fluid balance and useful in chronic fluid management conditions such as renal failure (RCUK, 2005; Docherty and McIntyre, 2002; Adam and Osborne, 1997).

In seriously ill patients urinary catheterisation is recommended to assist with accurate fluid balance measurement, as is regular vital sign monitoring including pulse, blood pressure (remember that the blood pressure may be normal initially as the peripheral vessels compensate), respiratory rate, pulse oximetry oxygen saturation and central venous pressure if available (RCUK, 2005; Docherty and McIntyre, 2002; Smith, 2000).

| TABLE 1. AVERAGE RECOMMENDED DAILY INPUT AND OUTPUT OF FLUID |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Intake:** 2,500ml | **Output:** 2,500ml |
| **Metabolic** | **GI tract** (100ml/day) | **Lungs** (300ml/day) | **Kidneys** (1,500ml/day) |
| (200ml/day) | **Skin** (600ml/day) | |
| **Ingested moist foods** | **(800ml/day)** |
| **Ingested liquids** | **(1,500ml/day)** |

**REFERENCES**


This article has been double-blind peer-reviewed.

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