Fluid management

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Abstract

Fluid management is an everyday part of medical care, but is commonly poorly understood. A basic understanding of fluid compartments and the structure and function of cell and capillary membranes is necessary for the rational choice of fluid therapy. This article addresses fluid compartments, different types of available intravenous fluid, and common issues in fluid management, along with some of the published evidence to support these choices of fluid. Suggestions for further reading are given.

Keywords Capillary membranes; cell membranes; colloids; crystalloids; fluid

Normal distribution

The management of patients' fluid and electrolyte status requires an understanding of body fluid compartments and their behaviour in health and disease. In adults, total body water (TBW) contributes 60% of body weight (Figure 1). Total body water is higher in males than females and as a percentage, decreases with age due to a reduction in adipose tissue. Neonates may have up to 80% of their body weight as TBW.

TBW is divided into the extracellular fluid volume (ECF) and intracellular fluid volume (ICF).

Extracellular fluid

This is all body water external to the cell, and accounts for around one third of TBW. It is subdivided into intravascular fluid and interstitial (third space) fluid.

Intracellular fluid

This is the water within the cells and accounts for 60% of total body water. The ICF is more heterogeneous in composition than the ECF, with different pH and ionic concentrations depending on the organ or tissue being considered.

Composition

The extracellular and intracellular compartments are separated by the cell membrane. The intravascular and interstitial compartments are separated by the capillary membrane. Both membranes are relatively impermeable to large molecules such as proteins and cellular components, but the capillary membrane is more permeable to smaller molecules such as ions and water. The permeability depends partly on the structural integrity of the cell or capillary membrane, and partly on the functional integrity of pumps, pores and transport mechanisms (Figure 2).

The traditional Starling model of fluid and ionic movement being determined by osmotic and hydrostatic forces has been superseded by a greater understanding of the complex interrelated factors such as hydrostatic pressure, molecular size, ionic forces and active transport involved in normal homeostasis. In health, the osmotic force generated by intravascular cells and proteins acts to retain water within the intravascular compartment, while the hydrostatic force generated by blood and fluid within the intravascular compartment acts to force water out into the interstitial compartment. The capillary endothelial glycocalyx helps regulate movement between these two compartments. This helps account for the marked difference in composition of different body compartments (Table 1).

Many disease states cause a release of interleukins, cytokines and other chemicals which disrupt both the physical and functional integrity of the capillary membrane, either by directly damaging the capillary endothelium and cell junctions, or by interfering with glycocalyceal function. The net result is a capillary leak syndrome. Clinically, this is manifest by extravasation of fluid from damaged capillaries, causing absolute or relative hypovolaemia, with consequent organ hypoperfusion and dysfunction, and tissue oedema (including pulmonary oedema).

Normal requirements

The normal daily maintenance water requirement for an adult in a temperate climate at rest is 35 ml/kg. This equates to 2.5 litres over 24 hours in an average 70 kg male. Normally fluid enters the body by diet (roughly 2 litres); the remaining 500 ml is produced via metabolism.

Fluid losses are predominantly by urine (1500 ml) and faeces. Approximately 1000 ml are lost via respiration and evaporation by the skin. This is increased during pyrexia – there is an estimated 10% increase in water losses for every degree temperature rise above 38 °C.[1]

The daily maintenance requirement for sodium is 1–1.5 mmol/kg/day, potassium 1 mmol/kg/day and approximately 50–100 g/day of glucose to limit starvation ketosis.

When considering a fluid strategy for a patient the following should be considered:

- The patient's normal requirements.
- Current volume status; the perioperative patient is often fluid deplete requiring a period of 'catch up'.
- Electrolyte status.
- Ongoing excessive losses (e.g. high output fistula, high gastric losses, third space losses). Examples such as these may also require consideration of electrolyte supplementation at a different amount to the above.
- Excessive fluid intake (e.g. drug infusions or antibiotics).

Assessment of hydration

Fluid management in the perioperative period involves maintaining the intracellular and extracellular fluid volumes. Assessment of the hydration status is vital in order to properly manage a patient's fluid requirement. This can be done by clinical history, examination and investigation results.

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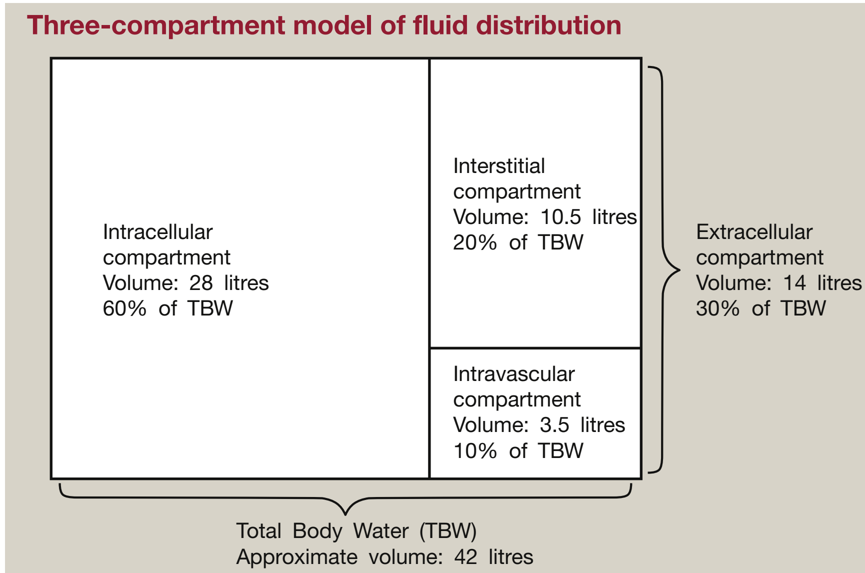

Figure 1

Clinical history

This may elicit causes of dehydration and volume depletion. Examples include bowel preparation, prolonged fasting, high stoma output, diarrhoea, vomiting or gastric losses, haemorrhage, drain output or third space losses.

Examination

A review of the observation chart should be performed in addition to a thorough examination. Signs of dehydration include dry mucous membranes, reduced skin turgor and prolonged capillary refill time.

Although the sensitivity and specificity of individual clinical signs is poor, clinical examination remains an important part of assessment of fluid status. Tachycardia, oliguria, and a reduced pulse pressure, progressing to hypotension are all recognized signs associated with hypovolaemia. An altered mental state and tachypnoea are other non-specific signs which may accompany this. The response of the observations to a fluid challenge forms an important part of the volume assessment. A fluid challenge is a technique where a defined amount of fluids are administered over a limited period of time under close monitoring to evaluate the patient's response and should be considered a separate entity to simple fluid administration. This is described in more detail in 'Advanced cardiovascular monitoring' on pages 97—104 of this issue. Urine output should be assessed — this should ideally be at least 0.5 ml/kg/hour. A reduction in this may indicate reduced

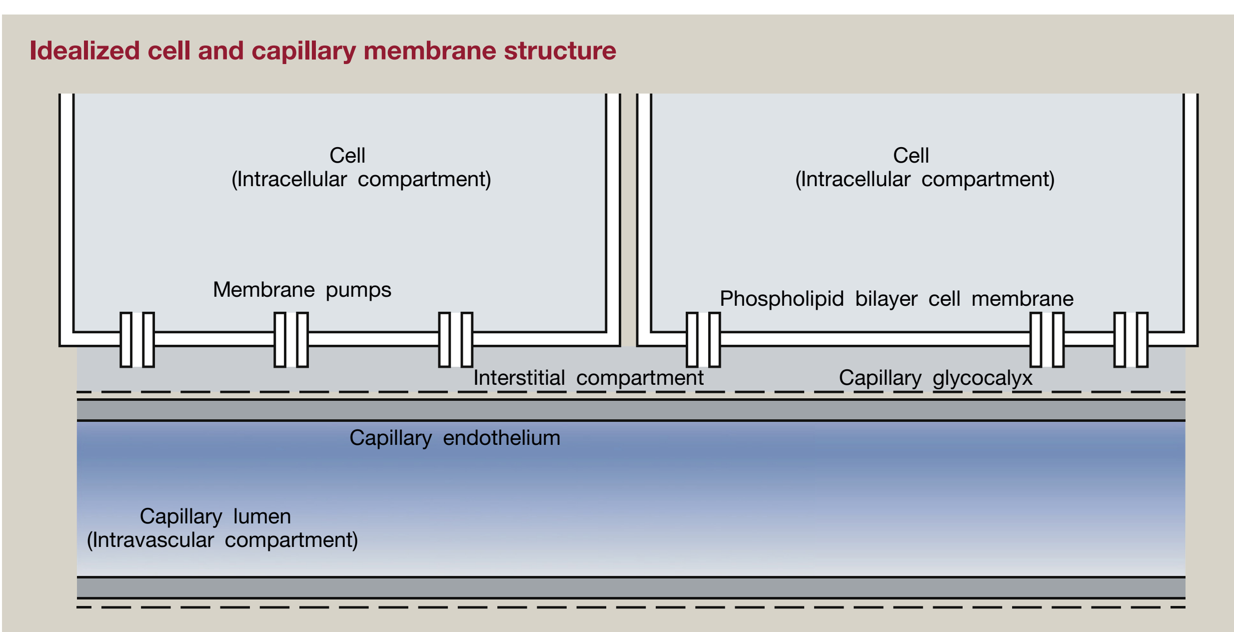

Figure 2