Perioperative fluid therapy for anaesthetists and intensivists

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Abstract

Understanding fluid physiology in homeostasis and disease is a key part of anaesthesia and intensive care. Decision making in perioperative fluid therapy is guided by knowledge of fluid compartments, shifts in illness and surgery and the composition of commonly used intravenous fluids. The implication of poor fluid management has significant outcomes for the patient, with both under-resuscitation and over administration of fluids leading to organ dysfunction and postoperative morbidity and mortality. Increasing use of haemodynamic monitoring within a guideline framework is advised. The evidence base for type of fluid, timing, and volume remain areas of investigation and ongoing clinical debate and it is vital as clinicians involved in perioperative care to continually update our knowledge of this area. Research is currently ongoing to determine whether restrictive, liberal or goal-directed fluid therapy is optimal to guide our practice. In the meantime, advice is to both individualize management to the patient condition and develop local protocols where possible.

Keywords Colloid; crystalloid; fluid responsiveness; glycocalyx; goal-directed; haemodynamic monitoring; perioperative

Royal College of Anaesthetists CPD Matrix: 1A01, 2A05

Learning objectives

After reading this article, you should be able to:

- define fluid compartments and composition in human body in health
- classify and describe commonly used intravenous (IV) fluids and the rationale for their use in certain clinical situations
- understand the term goal-directed therapy as it applies to perioperative fluid administration
- demonstrate an awareness of the main body of evidence available to guide fluid administration
- describe a strategy for perioperative fluid management for patients presenting for elective or emergency surgery, appreciating heterogeneity of the clinical condition

Introduction

An understanding of basic fluid physiology and management of perioperative fluid requirement is a fundamental aspect of anaesthetics and intensive care. It is, however, complicated and not fully understood with a wealth of conflicting literature to guide best practice. Homeostatic mechanisms exist to regulate composition of fluid and electrolytes within health, but these are altered in illness and following surgery. Knowledge of physiology and pathophysiology in these settings should guide fluid administration, using clinical and measurement tools to assess a dynamic process. Despite increasing recognition of the potential for harm with intravenous (IV) fluid administration, there still remains a lack of standardized practice for perioperative fluid administration, which likely reflects the heterogeneity of each clinical condition.

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Fluid physiology

Human fluid physiology is best understood in compartments which are in dynamic equilibrium. There are two main compartments, the intracellular (two-thirds) and extracellular (one-third). The extracellular space is further divided into the interstitial, intravascular and transcellular spaces detailed in Figure 1. Interstitial fluid (ISF) surrounds the cells and is composed of ions and proteins balancing intracellular physiology. It is removed by lymphatics and continually replaced. Sodium is the major determinant of extracellular fluid volume. Intravascular fluid is blood; a colloid suspension of globulins, ions and glucose, regulated by Starling hydrostatic and oncotic forces, and renal reabsorption. Water moves freely between intravascular and interstitial fluid, therefore the composition is similar, with changes in osmolality leading to water movement. The intracellular compartment is tightly regulated by ionic gradients and osmotic processes. Transcellular fluid is minimal, existing in the eye, central nervous system, pleural and peritoneal spaces. It is not in equilibrium with the other components. In health, the body has standard daily fluid and electrolyte requirements described in Table 1.

Fluid compartments in illness

In disease or surgical insult, fluid shifts between the compartments. Depletion from the intravascular space leads to hypovolaemia and reduced organ perfusion. To replace this, fluid will move from the intracellular space causing dehydration and disrupted intracellular processes. When the endothelium or glycocalyx is damaged or excess fluid is administered, fluid can shift into the interstitial space leading to oedema and further disrupting fluid homeostasis.

In response to hypovolaemia, the renin-angiotensin-aldosterone system (RAAS) responds causing vasoconstriction and increased salt and water retention via the kidneys.

The third space

Debate continues about the role of the 'third space'. The description essentially refers to the transcellular compartment,

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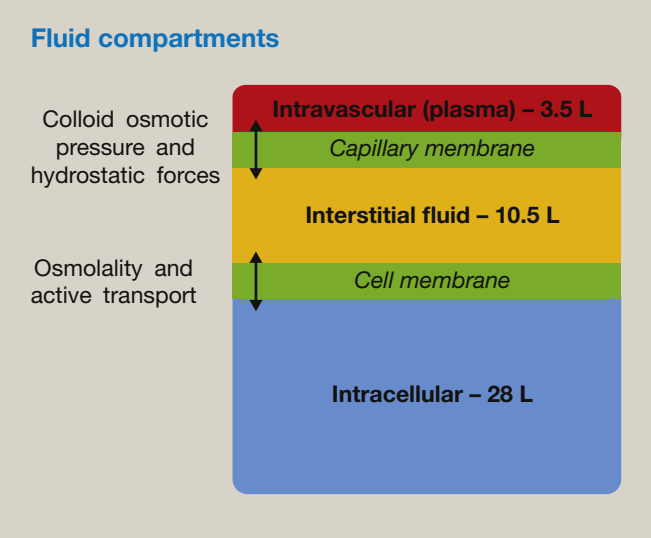

Figure 1

Fluid and electrolyte requirements in maintenance

Component	Requirement (mmol/kg/day)
Sodium	1.5–2
Potassium	1
Chloride	1–1.5
Magnesium	0.1–0.2
Calcium	0.1–0.2
Phosphate	0.2–0.5
Water	25–35 ml/kg/day
Energy	50–100 g/day glucose

Table 1

and the implication of third space loss is of large volume loss in acute illness to compartments that traditionally do not hold large volumes of fluid, including the peritoneal space. Traditional belief is that loss into this space necessitates larger volume resuscitation, but this is increasingly contested and argued that this belief is responsible for fluid over-administration.

Administered fluids and their composition

The two main fluid groups commonly used in both resuscitation and maintenance are crystalloids and colloids. The composition of commonly used intravenous fluids is detailed in Table 2.

Crystalloids are electrolyte solutions which vary in relative composition of ions, pH and osmolarity. Crystalloid administration leads to an immediate expansion of intravascular volume, but this will rapidly redistribute to extracellular spaces due to the fluid sodium content. Understanding physiology suggests that crystalloids are best suited to replacing electrolyte-rich extracellular loss such as gastrointestinal (GI) loss, urine output and perspiration.

Crystalloid concerns

Particular concern has been raised over use of excessive amounts of 0.9% saline, which due to high chloride content leads to hyperchloraemic acidosis. The mechanism for this is explained by the strong ion difference (SID) theory proposed by Stewart. Acid–base is not simply regulated by the concentrations of H^+ and HCO_3^- ions, but electrochemical neutrality is also required, governed by the 'strong ions' of which chloride is the most important anion. Administering a chloride load leads to a reduction in the SID, which leads to a reduction in SID. In order to maintain electrochemical neutrality, free water dissociation increases leading to an increase in hydrogen ion concentration and therefore acidosis. The clinical consequence of this effect is debated and a recent Cochrane review of perioperative use of buffered (physiological) versus non-buffered (normal saline) found no difference in mortality or organ dysfunction.[1] However, a recent multicentre randomized controlled trial has demonstrated harm with 0.9% saline versus balanced crystalloids in critically ill patients, with increased 30-day mortality and major adverse kidney events.[2] It is likely this very recent publication will be reflected in future or updated guidelines on fluid administration.

At the other end of the scale, dextrose/saline solutions can be utilized but with the associated risk of hyponatraemia in large volumes. Dextrose/saline solutions with sodium content below plasma become hypotonic when the glucose is metabolized. Water molecules are free to move between all compartments and distribute predominantly to the intracellular compartment owing to its larger volume. Using the compartment model; only 70 ml of 1 litre of 5% dextrose will remain intravascularly once redistributed, compared with 250 mls of 0.9% saline.

Colloids are solutions of higher molecular weight substances that exert an oncotic pressure, reducing movement out with the intravascular space. The rationale therefore is that colloids would be more effective in treating hypovolaemia as resuscitative fluids, with less volume required and less associated tissue oedema. Categories of colloid include human albumin solution (HAS) and synthetic colloids (gelatins, starches and dextrans). There have been a number of concerns about the use of synthetic substances due to the risk of anaphylaxis and the lack of a biological metabolic pathway. However, HAS is also not without risk.

- Albumin is available as 4.5% or 20%, is negatively charged promoting its maintenance within the circulation, but is a biological product with a potential risk for infection transmission. A multicentre randomized controlled trial in ICU patients demonstrated safety of 4.5% HAS compared with 0.9% saline in resuscitation.[3]
- Gelatins (Gelofusin), synthesized usually from bovine collagen, are still in use. Compared with other colloids, the molecular weight is small leading to a shorter intravascular time (1–2 hours).
- Starches (hydroxyethylstarch/HES) are moderate molecular weight colloids. They are no longer licensed for use in the UK due to clinical trials comparing crystalloid with HES 6% in ICU populations demonstrating increased need for renal replacement therapy[4] and increased 90 day mortality.[5]
- Dextrans, due to concerns over coagulopathy and renal failure, are no longer in frequent use.

Which fluid to use and when?

This following questions will continue to be debated throughout the literature of anaesthesia and intensive care practice; which

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