Fluid therapy for anaesthetists and intensivists

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Abstract

The prescription of intravenous fluids is common in hospitalized patients and is increasingly recognized as a potential source of harm if administered inappropriately. The recently published NICE guideline seeks to provide a simple and consistent approach to assessing, prescribing and re-evaluating fluid status in sick patients. There has been a long-running debate regarding the optimal fluid to prescribe which has shifted in recent years to consider not only which type of fluid to prescribe but also how much and when. This article summarizes the physiology of fluid and electrolyte homeostasis and the latest evidence for each of the common fluids available. We aim to highlight specific circumstances where the choice of fluid may vary from normal practice.

Keywords Colloid; crystalloid; fluid homeostasis; fluid management; goal-directed; perioperative

Royal College of Anaesthetists CPD Matrix: 2A05

Learning objectives

After reading this article, you should be able to:

- understand normal electrolyte and fluid homeostasis and how this is impacted upon by surgery and injury
- understand the types of intravenous fluid therapy and the individual indications and contraindications for their use
- outline the five Rs and the recommended approach to managing fluid prescription
- recognize situations where fluid management guidance may vary and outline the strategies for tailoring fluid prescription

Introduction

Fluid prescription may be the commonest medical therapy administered to hospitalized patients. It is also associated with harm to one in five patients.[1] Prescriptions are frequently written by the most junior medical staff who may underestimate the impact that intravenous fluids can have on homeostasis of fluid and electrolytes. Patients can suffer from the effects of too little or too much fluid or fluid inappropriately distributed though body tissues. Intravenous fluids often contain large amounts of electrolytes which may also cause harm if given in an inappropriate dose.

Fluid homeostasis

Normal fluid and electrolyte homeostasis of the intracellular, extracellular, interstitial and intravascular compartments is under precise physiological control to allow efficient cellular and organ function (Figure 1). The body's homeostatic mechanisms for adjusting fluid and electrolyte balance are affected by illness, injury or the stress response. The body's typical reaction to stress is to retain water and sodium through the increased release of anti-diuretic hormone (ADH), catecholamines and activation of the renin–angiotensin–aldosterone (RAAS) system. Due to the inflammatory response, increased capillary permeability allows albumin to leak into the interstitial space, resulting in intravascular fluid depletion and further activation of the RAAS system. RAAS activation can also result in the depletion of potassium, which further impairs the excretion of a sodium load. In addition, patients who are unwell may have increased losses due to fever, vomiting or diarrhoea coupled with a decreased oral intake either due to nausea or a period of being kept 'nil by mouth'.

Intravenous fluid administration is not physiologically 'normal' but is often required. It should be remembered that our aim is to reverse these pathological conditions and return the patient towards normal fluid and electrolyte balance. In doing so it is important to bear in mind that the patient's own homeostatic mechanisms are much more refined than our fluid prescribing and if patients can be encouraged to eat and drink and therefore avoid intravenous fluids, this is ideal.

There have been numerous guidelines developed to assist physicians when managing fluid balance,[2] yet the complexities of this are still underestimated and patients are still suffering harm. When seeking to manage fluid balance the UK National Institute for Health and Care Excellence (NICE) recommends[1] assessing 'the 5 R's':

- Resuscitation
- Replacement
- Routine maintenance
- Redistribution
- Reassessment.

It is important to make a thorough assessment of the patient, including their weight and recent fluid balance and to consider their typical daily electrolyte requirements (Table 1). The NICE guideline provides a structured approach to the assessment and management of fluid prescription.

Types of intravenous fluid therapy

Crystalloids

Crystalloids are water-based solutions containing electrolytes or sugars which may provide an osmolality close to plasma. Crystalloids will tend to redistribute rapidly once in the body. Those solutions containing only sugar will freely distribute between all body compartments. Those containing sodium will distribute

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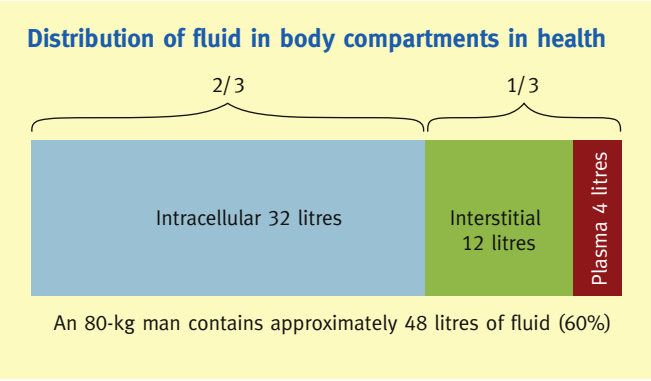

Figure 1

between the extracellular compartments of the body, as sodium is a mainly extracellular ion. The composition of the various solutions is given in Table 2.

As sugar-based solutions freely distribute, they provide the least benefit to increasing plasma volume. They are therefore predominantly used to provide electrolyte-free water as a routine maintenance fluid rather than in replacement or resuscitation. The sugar component should not be considered a significant energy substrate as the calorific benefits of a litre of fluid are minimal. A 1-litre bag of 5% glucose contains only 200 kcal, less than 10% of an adult's daily requirement.

Balanced solutions are those in which the sodium and chloride content more closely approximate to plasma. By substituting some of the chloride with a buffer they aim to reduce the incidence of hyperchloraemic acidosis. The buffer can be given in the form of bicarbonate, lactate, acetate or gluconate with potential advantages and disadvantages to each. The use of balanced crystalloid solution in favour of chloride rich solutions may reduce acute kidney injury during fluid replacement therapy on ICU.[3]

Colloids

Colloids contain large molecules in a crystalloid suspension which exert an additional osmotic pressure. Synthetic colloids include dextrans which are large sugar polymers (dextran 40, 70 and 110), gelatins (Gelofusin) and hydroxyethyl starches (Voluven/Volulyte). Plasma-based solutions include albumin and other blood components. They all carry an associated risk of anaphylaxis.

Typical daily water and electrolyte maintenance requirements

Substrate	Requirement
Water	1.5 ml/kg/hour
Sodium	1–2 mmol/kg
Potassium	1 mmol/kg
Chloride	1.5 mmol/kg
Phosphate	0.2–0.5 mmol/kg
Calcium	0.1–0.2 mmol/kg
Magnesium	0.1–0.2 mmol/kg
Energy	145 kJ/kg

Table 1

Gelatins: these are synthetic colloids made with gelatin, commonly from bovine collagen. The molecular weights of the molecules are relatively small at 30–35 kDa and duration within the intravascular space is relatively short (1–2 hours) compared to other colloids.

Dextrans: these colloids are made with large glucose polymer molecules. Dextrans were produced for fluid replacement due to their increased molecular weight, therefore having a longer duration of action within the intravascular space than gelatins. However, they are used infrequently due to the associated side effects which include renal failure secondary to deposition within the renal tubules, abnormal platelet function, coagulopathy and interference with blood cross-matching.

Starches: hydroxyethyl starches (HES) are composed of chains of amylopectin (glucose) molecules etherified and substituted with hydroxyethyl groups. Recently the Medicines and Healthcare products Regulatory Agency has removed HES from the UK formulary following a Cochrane review. This pulled together a growing body of evidence which showed that HES was associated with an increased risk of death and renal failure.[4]

Albumin: albumin is a naturally occurring colloid with an average molecular weight of 68 kDa. It is a product of plasma fractionation but due to the risk of variant Creutzfeldt–Jakob disease transmission, the plasma used is obtained from outside the UK. Commercially available solutions include 4.5%, 5% or 20% albumin suspended in saline.

Crystalloids vs colloids

There is ongoing discussion regarding the role of crystalloids and colloids and the decision of when to use them. The SAFE study[5] in 2004 demonstrated no benefit in using 4% albumin rather than 0.9% saline for fluid resuscitation. Similarly, the ALBIOS study[6] in 2014 demonstrated no survival benefit in adding albumin to a crystalloid based resuscitation approach in severe sepsis. The recent NICE guideline recommended using crystalloids as a first-line resuscitation fluid. In the UK the use of synthetic colloids is decreasing, with continued interest in the role of albumin in specific conditions.

Specific situations

Trauma

Recent improvements in trauma care have changed the way fluid resuscitation is delivered in a major trauma setting. The goals of damage control resuscitation are to minimise further injury and deliver adequate oxygen to the tissues without increasing blood loss. The concept of permissive hypotension targets a blood pressure of 70–80 mmHg in penetrating trauma and 90 mmHg in blunt trauma with a cerebrating patient. In practice this is achieved by targeting a palpable radial pulse. Guidelines restrict pre-hospital fluid to boluses of 250 ml of crystalloid to achieve a radial pulse. In hospital resuscitation is predominantly carried out with blood products in a 1:1:1 red blood cell:plasma:platelet ratio, with evidence that the use of non-blood-based fluids is associated with a worse outcome.[7]