Fluid Composition and Clinical Effects

Matt Varrier, MBBS, MRCP, Marlies Ostermann, PhD, MD, FRCP, EDIC*

KEYWORDS

• Crystalloid • Colloid • Fluid therapy • Critical illness • Balanced solutions
• Unbalanced solutions

KEY POINTS

- Crystalloids differ in electrolyte composition, pH, osmolarity, effect on acid base status, and strong ion difference and can be divided into balanced and unbalanced solutions based on their similarity with plasma.
- Colloids are crystalloid solutions containing oncotic macromolecules, which are protein or carbohydrate based. They differ in the type of macromolecule, electrolyte composition, and carrier fluid.
- The degree of volume expansion following fluid administration depends on the molecular weight and half-life of the components, function of the endothelial glycocalyx layer, endothelial integrity, and hydrostatic and osmotic pressure gradient between the intravascular and extravascular compartment.
- The adverse effects of different crystalloid and colloid fluids vary and include nephrotoxicity, anticoagulation, acid base disturbance, and anaphylactoid reactions.
- Knowledge of the characteristics of the different types of fluids and their potential effects following administration is essential to prescribe the most appropriate fluid according to the physiologic needs of patients.

INTRODUCTION

Fluids and oxygen are the most ubiquitous therapeutic interventions in critically ill patients. Typical indications for fluid administration range from simple replacement of insensible volume loss in patients unable to take fluids orally to correction of intravascular hypovolemia, augmentation of cardiac output, and administration of injectable medications and electrolytes.

Fluids exert their therapeutic effects by expansion of the intravascular, interstitial, and intracellular compartments.[1] There is evidence that their electrolyte composition

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King's College London, Guy's and St Thomas Hospital, Department of Critical Care, London, UK
* Corresponding author.
E-mail address: Marlies.Ostermann@gstt.nhs.uk

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and the particle size of components have an effect on the acid base status, renal function, and coagulation and may also affect patient outcome. The choice of fluid and the rate of administration should be guided by the physiologic needs of individual patients.[2–4] Knowledge of the composition of different types of fluids and their physiochemical characteristics is important to ensure that the right fluid is administered at the right dose and the right time for the right duration and tailored to the pathophysiologic phase of critical illness.[3–6]

The following review describes the characteristics of individual types of fluids, their effects on different organ systems, and potential indications in clinical practice.

TYPES OF FLUIDS

Crystalloids

Crystalloids are aqueous solutions containing minerals and/or salts of organic acids. They differ in electrolyte composition, pH, osmolarity, effect on acid base status, and strong ion difference and can be divided into balanced and unbalanced solutions based on their similarity with plasma[7] (**Table 1**).

Unbalanced crystalloids

Dextrose solutions Dextrose solutions contain glucose dissolved in either water (dextrose 5%, 10%, or 20%) or 0.9% sodium chloride (NaCl) (D5NS = 5% dextrose in 0.9% NaCl; D5 1/2 NS = dextrose 5% in 0.45% NaCl). They are hypotonic and can be used to provide glucose and free water in conditions associated with hypoglycemia or loss of water.

0.9% Sodium chloride Saline 0.9% is the most commonly used fluid worldwide. After infusion, it is rapidly distributed between the compartments of the extracellular space. In health, approximately 60% of the infused volume diffuses from the intravascular space into the interstitial compartment within 20 minutes of administration.[8] These fluid shifts are even faster in conditions associated with endothelial dysfunction.

NaCl 0.9% has a nonphysiologic ion content and supraphysiologic concentration of chloride (see **Table 1**). As a result, administration of 0.9% NaCl can lead to hyperchloremia and metabolic acidosis.

Sodium bicarbonate solutions Intravenous sodium bicarbonate ($NaHCO_3$) is available in different concentrations (1.26%, 1.4%, 4.2%, and 8.4%). In vivo, it dissociates to provide Na^+ and HCO_3^- anions and buffers excess hydrogen ions. Carbonic acid quickly dissolves to water and carbon dioxide (CO_2). The CO_2 is excreted via the lungs.

Balanced crystalloids

Balanced crystalloids are solutions with an ionic composition more similar to plasma than 0.9% NaCl. Several types are commercially available. They differ in their ionic makeup, osmolarity, tonicity, and type of metabolizable anion, such as acetate, lactate, and malate (see **Table 1**).

Ringer lactate solution has an osmolarity of 273 mosmol/L and can cause a small reduction in plasma osmolality.

Hartmann's solution is a slightly modified form of Ringer lactate.

Plasma-Lyte and Sterofundin contain electrolytes in concentrations that are more similar to plasma compared with Hartmann and Ringer lactate (see **Table 1**).

Colloids

Colloids are crystalloid solutions containing oncotic macromolecules that largely remain in the intravascular space and, thereby, generate an oncotic pressure