

# FLUIDS AND ELECTROLYTES 3

**Fluid therapy** Two broad categories of fluids are available, crystalloids and colloids. The crystalloids include 5% dextrose, 4% dex and 0.18% saline, 0.9% saline and Hartmann's solution. **Albumin** is a **natural colloid** whereas **artificial colloids** are synthesised from **gelatin, starches, and dextrans**. The carrier solution is usually 0.9% saline. Both are administered for volume replacement whereas only crystalloids are usually administered for maintenance. The **maintenance requirements** for an adult male is usually **2.5 L per day** (GI loss 100-200, insensible 500-1000, urinary loss 1500). Electrolyte replacement consists of **Na<sup>+</sup> of 75mmol** per day (most fluids will far exceed this although the kidneys can usually manage) and **K<sup>+</sup> of at least 40mmol** depending on urine output. Mg<sup>2+</sup>, Ca<sup>2+</sup> and Cl<sup>-</sup> do not require short term replacement. **Glucose** containing fluids are traditionally given to **reduce the sodium load, prevent hypoglycaemia and prevent catabolism**. **Caution** should be used to **prevent hyperglycaemia**, especially in patients such as those in surgery who will have a stress induced endogenous increase as well.

**Crystalloids** are solutions of sodium chloride or glucose or both in water. They are **usually isotonic** but can be hyper or hypo. Other electrolytes such as **K<sup>+</sup>**, and **lactate** and **calcium** may be **added to make composition more similar to plasma**. Lactate is metabolised in the liver and results in the consumption of H<sup>+</sup> ions to form HCO<sub>3</sub><sup>-</sup> and may therefore act as an **additional buffer**. After administration the fluids rapidly distribute **throughout the ECF**, thus they may expand the **plasma volume by 250ml following 1000ml infusion**. Excessive use may lead to oedema and other complications including hyperchloraemic acidosis.

Fluid	Glucose	Sodium	Chloride	Lactate	Potassium	Calcium	Osmolality
0.9% Normal Saline		150	150				300
5% Dextrose	278						278
Hartmann's Solution		129	109	29	5	2	274
3% Saline		450	450				900

**Colloids** contain **high molecular weight molecules** suspended in **saline**. They are termed **plasma expanders** because they exert **osmotic pressure** and hence retain the fluid in the intravascular compartment provided capillary membrane function is intact. The **duration of intravascular retention** of such solutions is depends on the **size** of the molecules, their **overall oncotic effect** and their **plasma half lives**. Differences in molecular weights and other characteristics determine their **safety and efficacy**. Ideal properties of a colloid are that it should be; stable with a long shelf life, pyrogen, antigen and toxin free, free from risk of disease transmission, plasma volume expanding effect lasts for several hours, metabolism and excretion do not adversely effect the recipient, no direct adverse effects, e.g. causing a coagulopathy.

**Albumin** is a relatively inexpensive **natural substance** derived from human plasma. Internationally the cost of albumin is significantly higher and therefore its use is reduced. Albumin in Australia is available in 4% and 20% concentrations. 4% is iso-osmotic and iso-oncotic with human serum. It has a nominal **osmolality of 250 mOsm/kg**, is **approximately isotonic** and the pH is approximately 7. Albumex<sup>®</sup> 4 is heated at 60° C for 10 hours and incubated at low pH to inactivate viruses. It has a short shelf life but can last 5 years if refrigerated. The composition of Albumex<sup>®</sup> 4 is as follows: Human Albumin 40 g/L, Sodium 140, Chloride 128, Octanoate 6.4. It produces a **very high colloid oncotic pressure and can expand the plasma volume significantly** by drawing in fluid from the ISF. The **intravascular half life is variable** due to leakage into the interstitial space and varies greatly with changes in the patient's condition. In normal patients around 5% of infused albumin leaks out per hour giving it an equivalent half life of approximately 16 hours. The **SAFE trial** demonstrated that there was **no difference in mortality in ICU patients resuscitated with either 0.9% saline or 4% albumex**. It should be noted however that there was **four times as many episodes of acute pulmonary oedema** in the albumin arm (1:300 vrs 1:1200).

**Gelatins** are **semi synthetic** polypeptides with a molecular weight of approximately 30 kDa prepared by hydrolysis from chemically modified bovine collagen. The most common form available in Australia is **Gelofusine** which is manufactured by Braun and imported from Switzerland. It is **isotonic and the succinylated gelatin** is suspended in sodium chloride solution. They provide isovolaemic volume replacement. They have **poor intravascular retention**, with plasma half lives of only **1-2 hours**. Gelatins **do not appear to influence haemostatic mechanisms** apart from a dilution of clotting factors. Although previously linked with significant risk of anaphylactoid reactions Gelofusine incidences of this occurrence have decreased.

**Dextrans** are **semi synthetic** highly branched polysaccharide molecules. Dextrans are commonly described by their average molecular weight (Dextran 40 or 70 kDa). Dextran **40 is eliminated from the kidney** but **70** passes into the tissues and **undergoes hydrolysis**. Dextrans have multiple effects, including plasma volume expansion, improved **microcirculatory flow**, and antiplatelet and antifibrin activities. Dextran 40 improves microcirculatory flow secondary to reduced blood viscosity and red cell aggregation and may be useful for patients undergoing vascular/graft procedures. Dextrans **induce an acquired von Willebrand's state** by reducing components of factor VIII. In the past they have been associated with severe hypersensitivity reactions and are not routinely used in Australia.

**Hydroxyethyl Starch (HES)** are **semi synthetic** colloids produced by hydroxyethyl substitution of amylopectin, a D-glucose polymer obtained from sorghum or maize. The pattern of hydroxyethyl substitution on glucose units reduces the susceptibility of hydrolysis by non specific amylases in the blood. The different HES products are commonly described by their weight-averaged molecular weight, and **range from 70 to 450 kDa**. **Small** molecules tend to **leak out** of the intravascular space and **larger** molecules **interfere with coagulation**. The **duration** of plasma volume expansion depends on the chemical characteristics of the HES and **varies from 6-24 hours**. They are comparable to 4% Albumex. Long term usage of this product leads to deposition in the reticuloendothelial system and there have been reports of severe debilitating **pruritis**. They also affect **platelet function** and **coagulation** and result in a **von Willebrand's like syndrome**. The newer generation lower molecular weight HES such as Voluven appear to have an improved safety profile).

	Source	Ave Molecular Weight (KDa)	Duration of Effect	Pharmaceutical Aspects	Coagulation Effects	Antigenic/ Infection Risk	Side Effects
Albumin Albumex 4%	Human Plasma	70	Highly variable 3-16 hours	Short shelf-life 5 years in fridge	Minimal effect	Concerns re CJD	APO in SAFE trial
Gelatins Gelofusine	Bovine Gelatin	30	1-2 hours	Long shelf-life stable	Minimal effect	Considered BSE free (US source)	Histamine assoc. symptoms
Dextrans Dextran 40	Sucrose	40 or 70	6 hours	Long shelf-life stable	Significant effect Aq. von Willebrand	Anaphylaxis/toid (lactobacilli Ag)	May obstruct renal tubules
Hydroxyethyl Starches Voluven 130	Sorghum/Maize	70 - 450	Proportional to MW 6 hours for 130 KDa	Long shelf-life stable	Significant effect Aq. von Willebrand	Can cause anaphylactoid rxns	Pruritis may be severe