Choosing between colloids and crystalloids for IV infusion

To maintain its finely tuned homoeostasis, the human adult body needs an average daily fluid intake of 2.5-3 litres (Moore and Cunningham, 2017). It also requires a constant balance in the levels of nutrients, oxygen and water to preserve a stable internal environment (Moini, 2016). This balance can be easily altered by illness or injury, resulting in a loss of one or all of these elements. This can lead to dehydration, hypoperfusion leading to reduced oxygen uptake, and organ dysfunction, so redressing the imbalance is essential.

A reduction in oral fluid intake, the redistribution of fluid in the vascular spaces and a decreased circulating volume need to be managed. Intravenous fluid therapy is one way of managing reduced fluid intake by reducing its effects and replacing lost fluids.

Recognising the signs and symptoms of fluid loss is necessary to identify the need for fluid administration. Knowledge of when to administer IV fluids, what type of fluid to administer, and why they are all essential. The National Institute for Health and Care Excellence’s (2017) guidance on IV fluid therapy in adults in hospital stresses the need for health professionals to understand the physiology of fluid and electrolyte balance. It also outlines five ‘Rs’ of fluid therapy: resuscitation, routine maintenance, replacement, redistribution and reassessment. This article provides an overview of fluid therapy, covering the NICE guidance and clarifying the differences between crystalloids and colloids, and when to use them.

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Abstract Hypovolaemia resulting from illness or trauma can precipitate imbalances in homoeostasis due to the loss of circulating fluid volume. By addressing hypovolaemia, homoeostasis can be restored, preventing hypoperfusion and subsequent organ dysfunction. Administering intravenous fluids can replace any lost circulating volume. The National Institute for Health and Care Excellence outlines five ‘Rs’ of fluid therapy: resuscitation, routine maintenance, replacement, redistribution and reassessment. This article provides an overview of fluid therapy, covering the NICE guidance and clarifying the differences between crystalloids and colloids, and when to use them.

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intravascular compartments). The movement of fluid between these spaces is continual. This enables cells to receive their necessary supply of electrolytes such as sodium, potassium and carbon. Along with oxygen, these are fundamental for cell performance (Peate and Nair, 2016).

Homeostasis is easily affected by any insult to the body, be it from illness, injury, trauma or medication. This imbalance can quickly lead to worsening illness and/or impede recovery. Hypovolaemia will reduce the circulating fluid volumes, resulting in reduced electrolyte and oxygen supply to the cells. A large reduction in fluid volume can result in hypovolaemic shock. Patients who go into hypovolaemic shock need fluid resuscitation to maintain their cardiac output and organ perfusion.

**NICE guidance**

NICE’s (2017) guidance on IV fluid therapy indicates that the assessment of patients should include:

- Physical examination;
- Observation of vital signs over time;
- Clinical presentation.

It also provides a set of parameters that may indicate that a patient needs fluid resuscitation (Box 2).

The parameters highlight the importance of assessing patients’ fluid and electrolyte balance. This involves ascertaining their history of fluid intake and any complaints of thirst. Consideration should also be given to the likelihood of insensible fluid loss – for example, from altered bowel function such as diarrhoea, or injuries such as burns. Comorbidities such as diabetes and cardiovascular disease can also lead to fluid and electrolyte imbalances.

The monitoring of vital signs, along with the assessment of jugular venous pressure and observation for possible oedema and postural hypotension, can help identify abnormalities in patients’ fluid and electrolyte balance. The National Early Warning Score (NEWS) and fluid balance and weight charts are essential tools. Additional tests such as full blood count and urea and electrolytes can confirm the need for IV fluid therapy (NICE, 2017).

**The ‘SRs’ of fluid resuscitation**

To ascertain the fluid requirements of patients who are acutely ill, an accurate assessment is needed and should include the ABCDE – airway, breathing, circulation, disability, exposure – approach (Frost, 2015). It is also important to investigate the cause of any potential fluid loss. Finding and treating that cause, along with the administration of fluid therapy, is essential to rule out refractory fluid loss. If not addressed, this persistent loss of circulating volume could lead to:

- The need for further fluid resuscitation;
- Increased volumes of fluid requirements;
- In severe cases, debilitating illness or death.

NICE (2017) recommends a bolus of 500ml of crystalloid solution (containing sodium in the range of 130-154mmol/L) over less than 15 minutes in patients requiring fluid resuscitation; this should be avoided for those who have any evidence of pulmonary oedema as a result of cardiac failure (Frost, 2015). This initial fluid resuscitation should be followed by a reassessment. If further fluid resuscitation is required, then fluid boluses of 250-500ml should be given. Patients needing continuous boluses of up to 2L will need further medical review.

**Routine maintenance**

Routine maintenance fluids are needed in patients who are at ongoing risk of fluid loss. Reasons for this could be poor fluid intake, recent surgery, bowel dysfunction and other comorbidities. Clinical examination, investigations, vital signs monitoring (including fluid balance and weight measurements) can all help to determine a patient’s need for routine maintenance fluids.

**Replacement**

Ongoing assessment of patients’ fluid balance is paramount. Assessment should focus on:

- Ensuring adequate hydration;
- Ensuring electrolyte balance;
- Checking for any potential fluid overload.

When ensuring normal electrolyte parameters are met, it is particularly important to consider the potassium levels. Alterations in potassium – either hypokalaemia or hyperkalaemia – can affect patients’ cardiac performance causing arrhythmias, heart failure and/or cardiac arrest. If continued fluid loss is suspected, this should be checked and losses monitored.

**Redistribution**

Redistribution of fluid can occur in critical illness. Fluid is lost from the circulatory volume and moves into the tissues; this is called ‘third space loss’ (Frost, 2015). This may be seen in patients with cardiac failure, renal failure or sepsis, and oedema may be present. To manage these patients effectively, increased monitoring, further assessment and investigations are needed. In some cases, specialist intervention, such as the monitoring of central venous pressure, kidney function tests or high dependency care, may be required.

**Types of fluids**

**Crystalloids**

Crystalloid solutions are isotonic plasma volume expanders that contain electrolytes. They can increase the circulatory volume without altering the chemical balance in the vascular spaces. This is due to their isotonic properties, meaning their components are close to those of blood circulating in the body.

Crystalloid solutions are mainly used to increase the intravascular volume when it is reduced. This reduction could be caused by haemorrhage, dehydration or loss of fluid during surgery.

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**Box 1. Five ‘Rs’ of intravenous fluid administration**

- Resuscitation
- Routine maintenance
- Replacement
- Redistribution
- Reassessment

*Source: National Institute for Health and Care Excellence (2017)*

**Box 2. Parameters for fluid resuscitation**

- Systolic blood pressure: <100mmHg
- Heart rate: >90 beats per minute
- Capillary refill: >2 seconds or peripheries cool to touch
- Respiratory rate: >20 breaths per minute
- NEWS: ≥5

*Source: National Institute for Health and Care Excellence (2017)*

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The most frequently used crystalloid fluid is sodium chloride 0.9%, more commonly known as normal saline 0.9%. Other crystalloid solutions are compound sodium lactate solutions (Ringer’s lactate solution, Hartmann’s solution) and glucose solutions (see ‘Preparations containing glucose’ below). Some crystalloid preparations containing additives such as potassium or glucose are used in specific circumstances, for example, in hypokalaemia and hypoglycaemia (Joint Formulary Committee, 2017).

**Table 1. Comparative summary of crystalloid and colloid solutions**

<table>
<thead>
<tr>
<th>Crystalloid solution</th>
<th>Colloid solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-life of 30-60 minutes</td>
<td>Half-life of several hours or days</td>
</tr>
<tr>
<td>Three times the volume needed for replacement</td>
<td>Replaces fluid volume for volume</td>
</tr>
<tr>
<td>Excessive use can cause peripheral and pulmonary oedema</td>
<td>Excessive use can precipitate cardiac failure</td>
</tr>
<tr>
<td>Molecules small enough to freely cross capillary walls, so less fluid remains in the intravascular spaces</td>
<td>Molecules too large to cross capillary walls, so fluid remains in intravascular spaces for longer</td>
</tr>
<tr>
<td>Inexpensive</td>
<td>More expensive than crystalloids</td>
</tr>
<tr>
<td>Non-allergenic</td>
<td>Risk of anaphylactic reactions</td>
</tr>
<tr>
<td>Suitable for vegetarian or vegan patients</td>
<td>Some preparations unsuitable for vegetarian or vegan patients</td>
</tr>
</tbody>
</table>

Source: Adapted from Pryke (2004)

**“The question of which plasma volume expander to use is controversial”**

Crystalloid solutions such as sodium chloride 0.9%, Ringer’s lactate and Hartmann’s solution need to be administered in larger volumes than colloid solutions. As two-thirds of the infused volume will move into the tissues, only the remaining third will stay in the intravascular space (NICE, 2017), leaving a diminished circulating volume in need of further fluid administration. This increased volume can cause unwanted side-effects such as oedema (NICE, 2017). Excessive amounts of infused sodium chloride 0.9% can produce hyperchlorectic acidosis due to its high chloride content, leading to renal dysfunction, resulting in a reduced glomerular filtration rate (NICE, 2017; Clarke and Malecki-Ketchell, 2016; Myburgh and Mythen, 2013). To reduce this risk, compound sodium lactate solutions (Ringer’s lactate/Hartmann’s solution) can be used (Joint Formulary Committee, 2017; NICE, 2017).

**Crystalloid preparations containing glucose**

Normal saline with the addition of 5% glucose is often used as a maintenance fluid. The main function of normal saline is to replace lost water, as it distributes the fluid throughout the body – thereby increasing total body water – but does not restore intravascular volume. The loss of water without loss of electrolytes is rare, but can be seen in patients with diabetes insipidus and hypercalcaemia. The additional glucose acts as a source of energy for patients who are unable to take oral food and fluids (Joint Formulary Committee, 2017).

Hyponatraemia is a side-effect of the excessive use of 5% glucose. This is countered by using mixed solutions, such as 0.18% or 0.45% sodium chloride in 4% glucose, or normal saline and 5% glucose (Frost, 2015).

**Colloids**

Colloids are gelatinous solutions that maintain a high osmotic pressure in the blood. Particles in the colloids are too large to pass semi-permeable membranes such as capillary membranes, so colloids stay in the intravascular spaces longer than crystalloids. Examples of colloids are albumin, dextran, hydroxyethyl starch (or hetastarch), Haemaccel and Gelofusine.

Caution should be used when administering hetastarch: exacerbated by the haemodilution effects of fluid administration, it can negatively affect platelet count, which can have a temporary negative effect on clotting times and coagulation (Marx and Schuerholz, 2010). Hypertension and tachycardia, cardiac failure, and pulmonary and peripheral oedema are all potential side-effects of the excessive administration of albumin, dextran or hetastarch (Frost, 2015; Marx and Schuerholz, 2010).

**Which fluid to administer?**

Crystalloids and colloids are plasma volume expanders used to increase a depleted circulating volume. Over the years they have been used separately or together to manage haemodynamic instability. Both are suitable in fluid resuscitation, hypovolaemia, trauma, sepsis and burns, and in the pre- , post- and peri-operative period. On occasion, they are used together (Frost, 2015).

Colloids carry an increased risk of anaphylaxis, are more expensive (Frost, 2015) and can cause unnecessary complications for vegetarian or vegan patients, as some preparations contain gelatin (Joint Formulary Committee, 2017). However, colloid solutions are less likely to cause oedema than crystalloid solutions. Colloids are less expensive, carry little or no risk of anaphylaxis, and pose no problem for vegetarian or vegan patients. However, evidence on any potential harmful effects of colloids is inconclusive. Table 1 summarises the main characteristics of crystalloid and colloid solutions.

**What the literature says**

The question of which plasma volume expander to use has long been controversial, resulting in several studies and systematic reviews. In recent years, numerous research studies have been performed in different clinical situations to compare crystalloids and colloids and look at their advantages and disadvantages (Skytte Larsson et al, 2015; Jabaley and Dudaryk, 2014; Yates et al, 2014; Burdett et al, 2012).

Jabaley and Dudaryk (2014) published a study that compared the effects of crystalloids and colloids in trauma patients who needed fluid resuscitation; as haemorrhage is the second most common cause of death from trauma, the need for haemodynamic stability and the maintenance of tissue and organ perfusion is essential. The study had limitations, including small sample size, funding and reporting bias, and the results were inconclusive.

Yates et al (2014) studied post-operative patients who were administered goal-directed fluid therapy. Their study demonstrated that colloids had no benefit over...
crystalloids in patients who had had colorectal surgery and confirmed that using crystalloids was just as effective.

Skeytte Larsson et al (2015) compared the effect of colloids and crystalloids on renal perfusion, filtration and oxygenation after cardiac surgery. Maintenance of oxygen delivery and renal perfusion are particularly important in the post-operative period to exclude the risk of acute kidney injury. Skeytte Larsson et al concluded that there was no difference in effectiveness between colloid and crystalloid solutions in ensuring adequate oxygen perfusion to the kidneys.

Smorenberg and Groeneveld (2015) studied the effects of fluid therapy on 42 septic and non-septic patients who had been assessed as hypovolaemic. Their study compared the urine output of those receiving crystalloid and colloid solutions and determined that patients receiving crystalloids had higher output volumes than those receiving colloids.

Perel et al (2013) performed a Cochrane systematic review of 78 randomised controlled trials comparing colloids and crystalloids as plasma volume expanders in patients who were critically ill. They concluded that colloids did not prove more effective than crystalloids in reducing the risk of death in patients with trauma or burns and in patients post-operatively.

Orbegozo Cortés et al (2014) published a structured review on crystalloid solutions. It included 28 studies that had investigated the physiological effects of crystalloid solutions in several different clinical situations. The review concluded that crystalloid solutions can have negative effects on electrolyte balance, coagulation and liver and kidney function. It found that normal saline increased blood loss and the need for blood transfusion, and that Ringer’s solution had higher output volumes and determined that patients receiving crystalloid and colloid solutions in several different clinical situations.

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