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Keywords Crystalloid/Colloid/Blood products/Osmolarity

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In this article...

- Causes of insensitive and sensitive fluid loss in critically ill patients
- Different types of intravenous fluids, their indications and side-effects
- Guidance on the treatment of fluid loss and fluid resuscitation algorithm

Selecting IV fluids to manage fluid loss in critically ill patients

Key points

Intravenous fluid therapy is one of the most common treatments in intensive care

Fluid loss leads to hypovolaemia and, if left untreated, to death

Crystalloids vary in their osmolarity and so have different indications

Colloids contain macromolecules that increase vascular pressure, resulting in plasma volume expansion

There is a lack of conclusive evidence on which fluid to use for treating fluid loss

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Abstract Critically ill patients admitted to intensive care settings may need to be administered intravenous fluids – for example, to restore their blood pressure or replace lost blood. A crucial question arising in the management of these patients is which type of fluid to use. To decide which fluid is most appropriate and safest, nurses working in critical care need to understand how the different types of fluids act on the human body. This article describes the three main types of fluids (crystalloids, colloids and blood products), their composition, mode of action, indications and side-effects.

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Intravenous (IV) fluid replacement is one the most common treatments administered in intensive care and other critical care areas (Myburgh and Mythen, 2013). Three types of fluids are used: crystalloids, colloids and blood products; in our experience, their use varies between hospitals and practitioners. It is important that nurses understand the different types of fluids, their mechanisms of action and side-effects. This article provides essential information on fluid resuscitation in critical care.

Fluid loss

Fluid loss can lead to hypovolaemia and, if left untreated, to death. In acutely ill patients, fluid loss can occur from insensible and/or sensible loss.

Insensible fluid loss cannot always be seen and measured; examples include sweating, fluid loss from the gastrointestinal tract (for example, via reabsorption) and fluid loss from the lungs (loss of H_2O via respiration), which can be up to 800ml in 24 hours (El-Sharkawy et al, 2017).

Sensible fluid loss, which can be seen and measured, can be due to diarrhoea, vomiting, haemorrhage, high output from drains or stomas, wounds or excessive diuretic therapy. Sepsis is another cause of fluid loss, as it causes an intravascular fluid deficit due to vasodilatation, venous pooling and capillary leakage (Marx, 2003).

Treatment of fluid loss

Acutely ill patients who experience fluid loss will need to be administered IV fluids. Where fluid loss is significant, replacement is urgent and this is known as fluid resuscitation. As with all drug treatments, IV fluids must be correctly prescribed by a doctor or a non-medical prescriber. One of the roles of nurses is to ensure this is done according to organisational policies. However, if the patient's condition is life-threatening, the National Institute for Health and Care Excellence advocates that nurses should be able to start IV fluids according to organisational policy until they are prescribed by a relevant practitioner (NICE, 2013).

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Indications for fluid resuscitation

In its guidance on IV fluid therapy in adults in hospital, the NICE (2013) lists the following criteria for fluid resuscitation:

- Systolic blood pressure <100mmHg;
- Heart rate >90 beats per minute;
- Capillary refill time >2 seconds or peripheries cold to touch;
- Respiratory rate >20 breaths per minute;
- National Early Warning Score ≥5 or more;
- Passive leg raising suggesting fluid responsiveness (Box 1).

To help health professionals in their decision-making, the NICE guideline includes algorithms for IV fluid therapy (Bit.ly/NICEFluidAlgorithms). The algorithm for fluid resuscitation (Fig 1) features three steps:

- **Step 1:** ABCDE (Airway, Breathing, Circulation, Disability, Exposure) assessment;
- **Step 2:** initiating treatment – the algorithm indicates how much fluid to give over a specific period; timing is important: if given too slowly, resuscitation will be less effective;
- **Step 3:** reassessment.

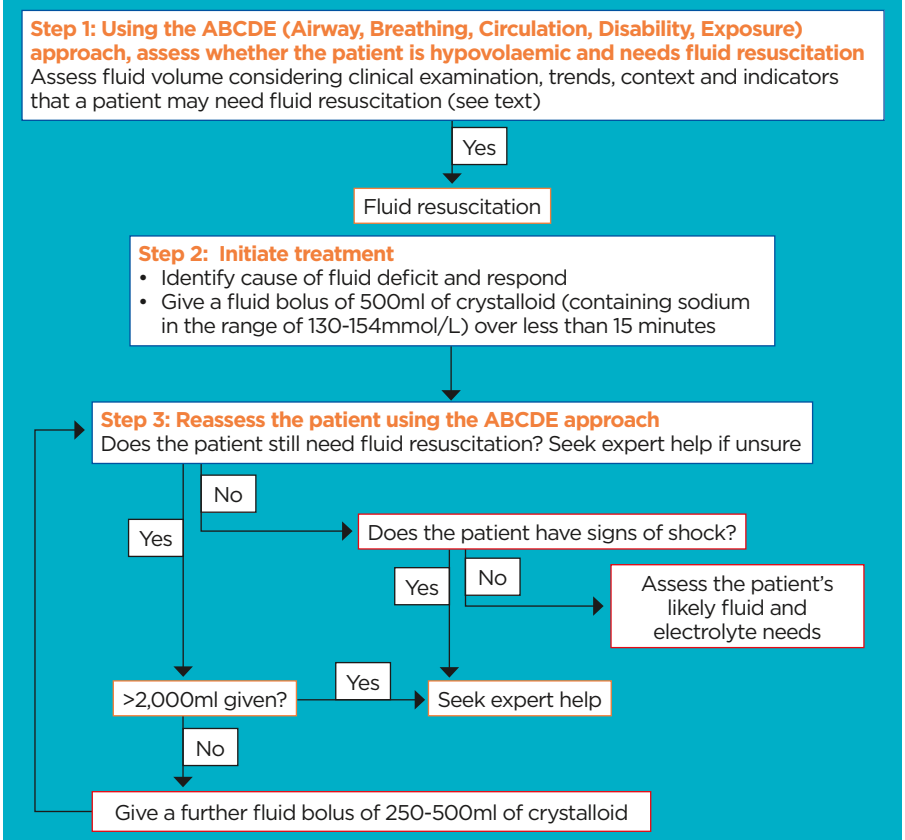
It is important to monitor patients during fluid resuscitation. Systemic observations should be undertaken frequently according to organisational policy. It is good practice to assign the monitoring to a specific nurse. Haemodynamic observations should include blood pressure (BP), heart rate, heart rhythm, oxygen saturation and capillary refill time. If the patient has a central venous catheter in situ, central venous pressure should be measured. Respiratory rate and urine output also need to be assessed and recorded. Fluid balance should be maintained or commenced and accurately recorded.

The observations will show trends in the patient's status and how the patient reacts to the treatment that you initiated. They also will allow early recognition of possible complications such as shock.

Box 1. How to ascertain fluid responsiveness

To ascertain a patient's responsiveness to fluid therapy, lay them down horizontally and raise their legs 45 degrees so the blood returns to the central circulation. If the blood pressure increases within 30-90 seconds, the patient is likely to be responsive to fluid therapy to restore blood pressure.

Fig 1. Fluid resuscitation algorithm in adults



Adapted from NICE (2013)

Nurses need to be able to identify the side-effects of IV fluids, which include fluid overload, oedema and anaphylactic reaction. Early recognition of complications and side-effects is essential to preserve patients' safety.

Crystalloids

Crystalloid solutions contain electrolytes and glucose. Osmolarity (Box 2) is an important property of crystalloids, which can be classified into four subgroups:

- Isotonic crystalloids – the most commonly used is sodium chloride 0.9% (normal saline);
- Balanced isotonic crystalloids – the most commonly used are Ringer's lactate and Hartmann's solution;
- Hypotonic crystalloids, which include dextrose saline, 0.33% NaCl (sodium chloride), 0.45% NaCl, 2.5% dextrose, 5% dextrose and 5% glucose (an isotonic fluid, which is quickly metabolised, leaving free water that is hypotonic).
- Hypertonic crystalloids, which include 3% NaCl, 5% NaCl, 7% NaCl, 10% dextrose, 20% dextrose and 50% dextrose (Lira and Pinsky, 2014; Gan 2011).

Properties and indications

Different types of crystalloids have different properties and will, therefore, be appropriate in different situations according to the cause of fluid loss and the patient's condition.

Isotonic crystalloids have a sodium and a chloride concentration of 154mmol/L and

Box 2. What is osmolarity?

Osmolarity measures the number of osmoles of solute particles per unit volume of solution. It is defined as the number of osmoles (Osm) of solute per litre (L) of solution and expressed as Osm/L (pronounced 'osmolar'). This value allows us to measure the osmotic pressure of a solution and determine how its particles will diffuse across a semi-permeable membrane separating two solutions of different osmotic concentrations (osmosis).

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a similar electrolyte concentration to plasma. With isotonic infusions, there is no significant fluid shift across cellular or vascular membrane for a normally hydrated patient (Lira and Pinsky, 2014; Gan, 2011). These fluids are usually used to treat low extracellular fluid loss (for example, in a dehydrated patient), in fluid challenge or during fluid resuscitation.

Balanced isotonic crystalloids contain less sodium and chloride than sodium chloride 0.9% (Lira and Pinsky, 2014; Gan, 2011); however, they contain potassium, calcium and lactate. They are called 'balanced' because their ionic composition is closer to the human body's plasma levels than other crystalloids. A post-operative patient at risk of fluid loss leading to electrolyte imbalance, for example, will benefit from balanced crystalloids.

Hypotonic crystalloids have a lower osmolarity than plasma (Lira and Pinsky, 2014; Gan, 2011), which means they cause fluids to shift from the intravascular space to the intracellular or interstitial space (Lira and Pinsky, 2014; Gan, 2011). They also help the kidneys excrete fluids and electrolytes, and are often used in patients with diabetic ketoacidosis.

Hypertonic crystalloids have a higher electrolyte concentration than plasma and, therefore, draw fluid from the intracellular and interstitial space into the intravascular space (Lira and Pinsky, 2014; Gan, 2011). They may be used to treat patients with cerebral oedema.

Side-effects and precautions

Isotonic crystalloids should be used with caution in patients with cardiac or renal disease, as there is a risk of fluid overload. Patients' sodium and chloride levels need to be monitored regularly to avoid hypernatraemia and hyperchloraemia.

The lactate contained in balanced isotonics is metabolised by the liver into bicarbonate (Adam et al, 2017), so these fluids should not be used in patients who cannot metabolise lactate due to liver disease or lactate acidosis; nor should they be administered to patients with pH >7.5. They should be used with caution in patients with renal failure because of the kidneys' inability to filter potassium. All isotonic crystalloids can cause peripheral and pulmonary oedema.

Hypotonic crystalloids should not be administered to patients at risk of increased intracranial pressure, those with liver disease or trauma or burns patients, mainly because these patients need to maintain a good intravascular volume.

Box 3. **Case scenario**

Tom Stevens* is admitted to the intensive care unit (ICU) via accident and emergency (A&E) for optimisation before surgery. Handover notes from the A&E nurse indicate a two-day history of diffuse abdominal pain, nausea and several episodes of vomiting. Mr Stevens has not been able to tolerate any oral intake. His bowel movements were normal until the previous day, when he had four liquid bowel movements. A central venous catheter, urinary catheter and peripheral cannula have been inserted in A&E.

On admission to the ICU, Mr Stevens has two episodes of haematemesis (vomiting of blood). His observations were as follows:

- Blood pressure 75/35mmHg;
- Mean arterial pressure 50mmHg;
- Heart rate 120 beats per minute;
- Respiratory rate 25 breaths per minute
- Oxygen saturation 91% (on room air)
- Central venous pressure +2mmHg
- Capillary refill time >3 seconds

As per national guidance (NICE, 2013), Mr Stevens would be initially treated as follows:

- Administer a 500ml crystalloid bolus over 15 minutes then reassess;
- If reassessment shows he still needs fluid, a further crystalloid bolus of 250-500ml can be administered;
- The cycle can be repeated if required until 2000ml of crystalloids has been administered;
- Regarding Mr Stevens' bleeding history, haemoglobin and haematocrit levels should be tested. This will indicate if a blood transfusion is needed and confirm if Mr Stevens' blood is diluted – this can occur due to fluid resuscitation;
- Medical staff should be informed of the situation so they can decide whether to continue with crystalloids resuscitation, or administer blood or colloids.

* The patient's name has been changed

With hypertonic crystalloids, the main risks are hypernatraemia and hyperchloraemia, so these fluids need to be given slowly and cautiously to avoid intravascular fluid overload and pulmonary oedema (Adam et al, 2013). It is also worth noting that 20% dextrose is an osmotic diuretic. Hypertonic solutions should not be given to patients with cardiac conditions, as there is a risk of fluid overload.

Colloids

Colloids contain macromolecules that increase vascular pressure (oncotic pressure), resulting in plasma volume expansion (PVE) (Lira and Pinsky, 2014; Gan, 2011). They can be classified into three main types according to how they are produced:

- Gelatins;
- Dextrans;
- Hydroxyethyl starches (HES).

Gelatins are prepared by hydrolysis of collagen (chemical breakdown of collagen due to a reaction with water). They also contain electrolytes such as sodium and chloride (Lira and Pinsky, 2014; Gan, 2011). Gelofusine belongs to this category.

Dextrans are biosynthesised from sucrose by leuconostoc bacteria using the enzyme dextrose sucrase (Gan, 2011; Lira and Pinsky, 2014). Dextrans contain sodium and chloride. Examples are dextran 40 and dextran 70 (the numbers relate to the solutions' molecular weight).

HES are synthesised from amylopectin, a water-soluble polysaccharide derived from maize or sorghum (Lira and Pinsky, 2014, Gan, 2011) and contain sodium and chloride. An example is Voluven.

Properties and indications

A key property of colloids is their duration of PVE, which is determined by their rate of loss from the intravascular space, which mainly occurs:

- Through the capillary endothelial barrier into the interstitial space;
- Through the renal glomerulus into urine (Gan, 2011).

Gelatins have a PVE of 0.2L after 90 minutes for one litre administered, which is equivalent to crystalloids. Dextrans and HES have a PVE of around 0.7L and 0.8L, respectively, for one litre administered (Gan, 2011). Because of their long PVE, colloids are often used in patients who are bleeding.

Side-effects and precautions

A notable effect of colloids is haemodilution, which occurs due to the amount of fluid kept in the intravascular space. This can affect homoeostasis.

Gelatins cause the least disturbance of homoeostasis but have been associated with reduced levels of some clotting

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factors (Gan, 2011). HES are the only colloids reported to produce coagulopathy and an increase in blood loss after surgery (Gan, 2011). Dextrans, which are effective antithrombotic agents, are associated with more significant homoeostatic disturbance (Gan, 2011).

Anaphylactic reactions have been described with all colloids; the incidence of severe reactions seems to be higher with gelatins. Colloids, especially HES, also seem to affect kidney function (Niemi et al, 2010).

Blood products

Blood products used for fluid therapy include:

- Red blood cells – one of the components of blood; they are derived from whole blood by centrifugation (Dean, 2005);
- Fresh frozen plasma (FFP) – the liquid part of blood; it contains all soluble coagulation factors, including factors V and VIII (Prowle et al, 2010; O'Shaughnessy et al, 2004);
- Cryoprecipitate – contains a concentrated subset of FFP components including fibrinogen, factor VIII, von Willebrand factor and factor XIII (Curry et al, 2015);
- Platelets – one of the components of blood; a single platelets unit is derived from one unit of whole blood and should be used within five days (Kaufman et al, 2015);
- Albumin – a protein synthesised by the liver.

Properties and indications

Red blood cells can be administered to maintain an acceptable haemoglobin level and blood volume in patients with blood loss, thereby ensuring a good delivery of oxygen.

FFP is administered in specific cases, such as liver disease, severe infection or disseminated intravascular coagulation (Adam et al, 2017).

Platelets stop bleeding, so they can be administered to patients who are bleeding (or at high risk of bleeding) and/or who report a low platelet count.

Albumin has plasma expansion properties (Barron et al, 2014) and also raises vascular pressure (Wiedermann et al, 2010). It can be used to compensate fluid lost from an ascites drain, for example.

Side-effects and precautions

A transfusion of blood products will increase iron and potassium levels. All blood products must be administered according to organisational protocols; attention must be paid to the risk of anaphylactic reactions and the compatibility of the product with the patient's blood group needs to be carefully checked.

Inconclusive evidence

The vast number of studies published on IV fluid therapy show the importance of the subject, but the evidence is inconsistent, in particular on the question of whether to administer crystalloids or colloids (Perel and Roberts, 2013; Phillips et al, 2013).

Annane et al, (2013) found no difference in terms of mortality between colloids and crystalloids at 28 days, although colloids seemed better than crystalloids at 90 days in terms of patient outcomes. A few studies reported no evidence of benefits using colloids instead of crystalloids (Lira and Pinsky, 2014; Myburgh and Mythen, 2013; Perl et al, 2007), highlighting that it was difficult to justify the use of colloids because of their high cost.

However, other studies showed an increase in mortality with the use of colloids (Taylor and Bromilow, 2013; Zarychanski et al, 2013; Gan, 2011). Others again showed that colloids increased the risk of acute kidney injury and the need for renal replacement therapy (Mutter et al, 2013; Myburgh and Mythen, 2013; Taylor and Bromilow, 2013; Zarychanski et al, 2013; Wiedermann et al, 2010).

While the studies cited above suggest colloids are less safe than crystalloids during resuscitation, crystalloids are not harmless and do have side-effects (Myburgh and Mythen, 2013). Most of these studies raise the question of the safety of colloids, especially HES; gelatines have been less investigated than HES and their safety cannot be confirmed (Thomas-Rueddel et al, 2012).

Amid this lack of conclusive evidence, the NICE 2013 guidance gives clear indications on how to treat fluid loss in critically ill patients. Nurses should refer to the guidance and any local protocols and policies. The case scenario in Box 3 describes the case of a patient who needed fluid therapy to maintain his blood pressure. By developing their knowledge and understanding of the different types of fluids and their effects on the human body, nurses can improve their ability to offer evidence-based care. **NT**

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