Abstract

A balance between the volume of fluid taken in by the human body, and the volume of fluid excreted, is essential for life. Body fluid balance, which is maintained via various homeostatic mechanisms, can be disrupted by injury or disease. Prompt action is usually required to replenish fluid volumes and restore homeostasis, which is achieved via intravenous (IV) fluid therapy. Nurses will often encounter patients with a disrupted fluid balance, particularly in critical care. They will be involved in assessing patients’ fluid status and administering and monitoring therapy. Therefore, nurses have an important role in ensuring the safety and effectiveness of IV fluid therapy. This article provides an overview of the principles and aims of IV fluid therapy, regulation, outlines the principles of patient assessment and indications for IV fluid therapy, and details its potential risks and complications.

Aims and intended learning outcomes

The aim of this article is to assist nurses in understanding how the human body maintains fluid balance, what may disrupt fluid balance, and how intravenous (IV) fluid therapy can restore this. After reading this article and completing the time out activities you should be able to:

- Recognise the risks of inappropriate IV fluid therapy.
- Explain fluid balance and the homeostatic mechanisms that regulate it.
- Assess patients’ fluid status and their IV fluid therapy requirements.
- Outline the two main types of IV fluids and their mechanisms of action.
- Understand the risks and complications of IV fluid therapy.

Introduction

IV fluid therapy is commonly used in clinical practice, notably in secondary care, but also in the pre-hospital setting (Seymour et al 2014) and in primary care (Payne 2019). In hospital, many adult inpatients require IV fluid therapy to correct their fluid and/or electrolyte balance or prevent it from deteriorating (National Institute for Health and Care Excellence (NICE) 2017). Therefore, IV fluid therapy is an integral component of nursing practice.

The Royal College of Nursing (RCN) (2016) standards for infusion therapy state that, depending on their scope of practice, the involvement of healthcare professionals may include patient care, care of the device that administers the fluids, procurement of consumables, implementation of quality or safety improvement initiatives, and research activities. Nurses may be tasked with assessing the need for IV fluids, monitoring their administration, inserting and managing peripheral or central vascular access devices, and taking all necessary infection prevention and control measures (Dougherty and Lister 2015). These tasks may be undertaken by various members of staff, including nurses, nursing associates and...
healthcare assistants, depending on their competencies and scope of practice (RCN 2016, Nursing and Midwifery Council (NMC) 2018). Nurses with non-medical prescribing qualifications may also prescribe IV fluids (NMC 2019).

It is estimated that as many as one in five patients receiving IV fluids and electrolytes experience complications or morbidity because of inappropriate administration, primarily as a result of prescribing errors and suboptimal recording and monitoring (NICE 2017). Reasons cited for these issues include a lack of knowledge around IV fluid therapy, a lack of relevant experience and a lack of specific staff training (NICE 2017). Inappropriate IV fluid therapy may cause medical issues such as tissue hypoperfusion (decreased blood flow to tissues) and oedema, which can increase morbidity, mortality and the length of hospital stay (Hoste et al 2014).

Healthcare professionals need to ensure patients receive the most appropriate infusion therapy (Hallam et al 2016), so it is essential that they have the knowledge and skills to undertake their role safely and effectively. NICE (2017) published a clinical guideline for IV fluid therapy in adults in hospital, as well as a guideline on recognising and responding to deterioration in acutely ill adults in hospital (NICE 2007).

**Composition of fluid in the body**

In an average male, 60% of body weight is fluid, while in an average female, 55% of body weight is fluid (Frost 2015). Body fluid comprises water and dissolved constituents such as electrolytes (Macintosh 2011). It is essential to life and has several crucial functions, including controlling temperature, removing waste products, maintaining acid-base balance, and delivering nutrients and diffused gases to cells (Baumberger-Henry 2007).

Body fluid is found within cells (intracellular compartment) and outside cells (extracellular compartment). Intracellular and extracellular fluid volumes are separated by the walls of cells and capillary vessels – thin semipermeable membranes through which fluid is continually passing (Watson 2018). Around two thirds of body fluid is intracellular and one third is extracellular (McGloin 2015).

The extracellular compartment divides into the interstitial compartment (space surrounding cells) and intravascular compartment (space within blood vessels). Intravascular body fluid is known as plasma. Plasma is the liquid component of blood, comprising 55% of its volume; blood cells are the solid component of blood, making up the other 45% (Watson 2018). In an adult, around 3L of extracellular fluid is plasma, which contributes to a total circulating blood volume of around 5L (McGloin 2015). The movement of fluid in and out of the intravascular space is regulated by the opposing forces of hydrostatic and osmotic pressure. The walls of capillary vessels are permeable to water and small ions, but impermeable to the large protein molecules found in plasma (Macintosh 2011).

**Maintaining fluid balance**

Fluid balance is the balance between the volume of fluid taken in and the volume of fluid excreted by the body. Maintaining fluid balance is a critical bodily function (Popkin et al 2010). In homeostasis (balanced state of body function), optimal hydration is achieved, since the volume of fluid taken in matches the volume of fluid excreted by the body (Marieb and Hoehn 2016).

Maintaining the body’s fluid balance is predominantly achieved via renal activity (McLafferty et al 2014). Fluid intake and urine output are the main mechanisms for maintaining fluid balance (Gouldon 2016). A drop in circulating plasma volume can affect bodily functions such as oxygen delivery to the tissues and cells, for example through blood loss. Such a change will trigger compensatory mechanisms aimed at re-establishing homeostasis.

One compensatory mechanism is that initiated by the renin-angiotensin-aldosterone system (RAAS), which has an important role in the body’s response to plasma volume changes. A fall in blood pressure triggers a sequential renal and neural and/or adrenergic response (Tait 2015). The kidneys secrete renin (a serine protease protein and enzyme) and release it into the blood. Renin activates the RAAS pathway, prompting the adrenal cortex to secrete the hormone aldosterone. Aldosterone causes the renal tubules to increase their reabsorption of sodium, which releases water back into the blood, thereby expanding plasma volume and increasing blood pressure. Aldosterone also has an important role in potassium regulation. When the levels of potassium in extracellular fluid increase, so do aldosterone levels, which causes additional potassium ions to be excreted via the kidneys in the urine. This contributes to maintaining electrolyte balance in the body (Marieb and Hoehn 2016).

Another compensatory mechanism is provided by the vasoconstricting action of angiotensin II. Renin secreted by the kidneys converts angiotensinogen to angiotensin I. Angiotensin I is subsequently converted to angiotensin II by angiotensin-converting enzyme (ACE) secreted by the vascular endothelium, particularly in the lungs. Angiotensin II is a potent vasoconstrictor and causes blood pressure to rise (Casey 2012).

Plasma volume is further regulated by the action of antidiuretic hormone (ADH), a small peptide hormone secreted by the posterior pituitary gland. When osmoreceptors and baroreceptors detect a decrease in osmolality and blood pressure, they trigger the release of ADH. ADH heightens the sensation of thirst, which prompts patients to increase their oral fluid intake, thereby increasing body fluid volume (Marieb and Hoehn 2016).

**Alteration of fluid balance**

Fluid loss from the body contributes to an altered fluid balance and can be categorised as sensible or insensible. Sensible fluid loss is readily measurable (Kear 2017), while insensible fluid loss is not. Box 1 provides examples of sensible and insensible fluid losses.

The body’s fluid balance can be altered by disease and injury (Frost 2015). Pathological causes
of fluid loss include haemorrhage, dehydration, sepsis, burns, severe diarrhoea and vomiting, and excessive urination (Gouldon 2016). In a healthy person, the body’s compensatory mechanisms described in the previous section will be effective in maintaining fluid balance; however, in ill health, if lost fluid is not replaced, these mechanisms will eventually fail (Dougherty and Lister 2015).

When blood is lost from the intravascular compartment – for example, through haemorrhage – the body compensates by drawing fluid from other areas. For every 1L of blood lost, within ten minutes, 600mL of fluid will move from the cellular and interstitial spaces into the intravascular space. This is known as internal transfusion (Gouldon 2016). However, failure to replace the lost fluid will eventually lead to cellular and organ dysfunction, which may ultimately result in organ failure and death (Goldstein 2014). Therefore, it is vital to restore fluid balance by replacing lost fluid.

A decrease in volume of circulating plasma in the body is known as hypovolaemia. Shock is a state of impaired delivery of oxygen to, or use of oxygen by, the cells (Adam et al 2017). Hypovolaemic shock occurs as a result of a loss of blood, plasma or extracellular fluid (Tait 2015). It requires the re-establishing of fluid balance and replenishing of circulating plasma volume to restore tissue perfusion and oxygen delivery (Macintosh 2011).

**Key points**

- The body maintains its fluid balance primarily through renal activity. A change in this balance affects circulating plasma levels and triggers compensatory mechanisms aimed at restoring fluid balance.

- The body’s fluid balance can be altered by disease and injury. Pathological causes of fluid loss include haemorrhage, dehydration, sepsis, burns, severe diarrhoea and vomiting, and excessive urination.

- Patients who may require intravenous (IV) fluid therapy to restore fluid balance should be first assessed using the ABCDE (airway, breathing, circulation, disability, exposure) approach.

- Assessing a patient’s fluid status comprises several elements, including National Early Warning Score 2, fluid input and output, and examining biochemical markers.

- The two types of IV fluids available are crystalloids and colloids; which type is used will depend on the clinical situation.

### Box 1. Examples of sensible and insensible fluid losses

<table>
<thead>
<tr>
<th>Sensible fluid loss</th>
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<tbody>
<tr>
<td>Urination</td>
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<tr>
<td>Defaecation</td>
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<tr>
<td>Blood loss</td>
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<tr>
<td>Wound and gastric drainage</td>
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<td>Vomiting</td>
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<table>
<thead>
<tr>
<th>Insensible fluid loss</th>
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<tbody>
<tr>
<td>Perspiration</td>
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<tr>
<td>Breathing</td>
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(Adapted from Kear 2017)

**Assessment of fluid status**

In its guideline on deterioration in acutely ill adults in hospital, NICE (2007) recommends monitoring all patients using physiological track-and-trigger systems. One such system is the National Early Warning Score 2 (NEWS2) (Royal College of Physicians (RCP) 2017), which uses six parameters: respiratory rate, oxygen saturation, temperature, systolic blood pressure, pulse rate and level of consciousness. It also incorporates new-onset confusion, emphasises the importance of considering serious sepsis in patients with known or suspected infection, and features a dedicated section for patients with hypercapnic respiratory failure in whom oxygen saturations of 88-92% are clinically recommended (RCP 2017). However, one limitation of NEWS2 is that urine output does not contribute to the scoring (Grant 2018).

Patients who may require IV fluid therapy should be carefully and comprehensively assessed. The ABCDE (airway, breathing, circulation, disability, exposure) approach (Resuscitation Council (UK) (RCUK) 2019) provides a systematic approach to the assessment of deteriorating patients (Smith and Bowden 2017). Patient assessment using the ABCDE approach ensures that vital signs are investigated in a logical sequence and that any life-threatening issues are prioritised. Once an initial assessment has been completed, regular re-assessments should be undertaken (RCUK 2019).

The clinical assessment of a patient’s fluid status comprises several elements (Scales and Pilsworth 2008), including:

- Recording vital signs and NEWS2.
- Monitoring fluid input and output.
- Assessing and observing urine output.
- Considering insensible fluid loss.
- Measuring capillary refill time.

**TIME OUT 1**

Reflect on a patient you have cared for with hypovolaemia. What methods did you use to assess the patient? What features were present that could have explained the fluid imbalance? What had caused hypovolaemia?

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Capillary refill time >2 seconds or peripheries cold to touch.
Respiratory rate >20 breaths per minute.
NEWS2 score ≥5.
Passive leg raising test suggests fluid responsiveness.

TIME OUT 2
In your clinical area, locate and study a completed patient fluid balance chart. Has it been completed correctly? If not, what factors may explain why the chart was incomplete or not completed correctly? What could be done to improve fluid chart completion?

Fluid input and output
Monitoring fluid input and output, usually over a 24-hour period (Jevon et al 2012), is essential in determining whether the patient is adequately hydrated (Scales and Pilsworth 2008). Box 2 lists the main sources of fluid input and output that need to be recorded on the patient’s fluid chart. Fluid charts must be accurately completed, but there is evidence suggesting that this is not always the case. Vincent and Mahendiran (2015) conducted a project to improve the quality of fluid balance monitoring on the respiratory ward of one large district general hospital. Their baseline data showed that, among patients who were having their fluid input and output monitored, the average chart completion rate was 50%, the average chart accuracy was 41%, and monitoring was clinically indicated in 53% of patients.

Urine output
Assessing and observing urine output will assist in gauging the patient’s fluid status. In an adult, the minimum acceptable volume of urine is 0.5mL/kg/hour (Adam et al 2017). In hypovolaemic states, blood flow is prioritised to the heart, brain and lungs; a normal urine output; therefore, indicates adequate renal blood flow and thus adequate vital organ perfusion. Urine should be a pale straw colour, but in patients who are fluid depleted, it will be increasingly concentrated and therefore darker (Scales and Pilsworth 2008).

Insensible fluid loss
While it is not readily measurable, the approximate volume of insensible fluid loss in adults is 650mL/day (Boron and Boulpaep 2016). It is important to be aware that factors such as pyrexia and increased respiratory rate can increase insensible fluid loss.

Capillary refill time
Capillary refill time is measured by applying pressure on a fingertip on an arm that has been raised to the level of the heart for five seconds, causing the blood to withdraw and the skin to turn pale, and observing how long it takes for the skin to regain its normal colour. A capillary refill time >2 seconds may indicate hypovolaemia (Jackson 2011). However, the use of skin colour as a diagnostic marker is not necessarily accurate and may be misleading in certain patient groups; for example, in patients with sepsis the inflammatory response causes peripheral vasodilation (Jackson 2011).

Biochemical markers
Patients who are dehydrated may present with raised levels of urea, creatinine, lactate, haematocrit and haemoglobin (Frost 2015), so biochemical markers should be examined. Laboratory investigations should include full blood count and urea, creatinine and electrolytes (NICE 2017).

Bedside echocardiography
Bedside echocardiography is increasingly used to determine patients’ fluid needs and evaluate the effects of IV fluid therapy. This technique has many benefits, including provision of real-time data and portability of the device used, and is safe and non-invasive (Casaroto et al 2015).

TIME OUT 3

Intravenous fluid therapy
In IV fluid therapy, a solution, medicine, blood or blood product is infused directly into a vein (Perry et al 2017), either to maintain fluid balance when oral or enteral intake is inadequate, or to replace lost fluid. Using the IV route is an effective way of administering fluids to patients who are unable to meet their fluid intake requirements orally (Rees Doyle and McCutcheon 2015) or in whom the enteral route is not feasible. Using the IV route is also a rapid and effective method of administering fluids or medicines in emergency situations. Therefore, fluid resuscitation is one of the most common interventions in patients with hypovolaemia (Walter 2016) and is one of the most important strategies in the early management of patients who are critically ill (Rhodes et al 2016). For patients presenting with major haemorrhage secondary to trauma, fluid therapy using an isotonic crystalloid solution should be initiated in patients with hypotension (Spahn et al 2019).

The NICE (2017) guideline Intravenous Fluid Therapy in Adults in Hospital provides comprehensive guidance regarding indications and differentiating between ‘bolus’ and ‘maintenance’ regimes. A bolus regimen is used in patients who require IV fluid resuscitation, while a maintenance regimen is for patients who require routine maintenance (NICE 2017). IV fluid therapy should be based on five principles, known as the ‘five Rs’ (NICE 2017):

- Rapid resuscitation – urgent fluid resuscitation may be required following haemorrhage, infection, trauma or burns (Lewis et al 2018).

Box 2. Main sources of fluid input and output

<table>
<thead>
<tr>
<th>Sources of fluid input</th>
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<tbody>
<tr>
<td>Oral and nasogastric feeds</td>
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<tr>
<td>Intravenous infusions and fluids</td>
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<tr>
<td>Subcutaneous and rectal infusions</td>
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<table>
<thead>
<tr>
<th>Sources of fluid output</th>
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</thead>
<tbody>
<tr>
<td>Urine</td>
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<tr>
<td>Faeces</td>
</tr>
<tr>
<td>Vomit</td>
</tr>
<tr>
<td>Leakage from drains and stomas</td>
</tr>
<tr>
<td>Aspirate from nasogastric tubes</td>
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(Adapted from Dougherty and Lister 2015)
Routine maintenance – routine maintenance of fluid balance may be required, for example in patients who are unable to meet their fluid requirements through the oral or enteral route but are otherwise well in terms of fluid and electrolyte balance and handling. This includes patients who have had a stroke that has caused dysphasia, patients who are nil by mouth before surgery and patients with gastrointestinal obstruction. Once patients have regained the ability to meet their fluid requirements via the oral or enteral route, IV fluid therapy should be discontinued as soon as possible (Powell-Tuck et al 2011).

Redistribution – urgent IV fluid therapy may be required for redistribution purposes in patients experiencing disorders that affect the distribution of fluid in the body, such as sepsis and anaphylaxis. In sepsis, the inflammatory response causes vasodilation and fluid leak from the capillaries, and therefore causes an increase in vascular space that can lead to hypovolaemia (Adam et al 2017).

Replacement – replacement IV fluids may be required to treat existing deficits or ongoing external losses, usually from the gastrointestinal or urinary tract; for example, in patients with gastroenteritis or diabetic ketoacidosis (Finfer et al 2018).

Reassessment – frequent reassessment of patients’ response to, and ongoing need for, IV fluid therapy is essential (Hoste et al 2014). NICE (2017) provides detailed guidance on the frequency of re-assessment.

TIME OUT 4

Referring to national guidelines and local policy as well as this article, prepare a short oral presentation for junior nurses on the various types of IV fluids and what differentiates them.

Types of intravenous fluid

There are two main types of IV fluids, crystalloids and colloids, which both act as plasma volume expanders. Understanding their nature and composition will assist healthcare professionals in selecting the most appropriate fluid, which will prevent complications and improve patient outcomes (McClelland 2014). The choice of IV fluid directly affects fluid distribution in the body. All IV fluid initially enters the intravascular compartment; however, how much of it remains in the intravascular compartment and how much passes into the interstitial and intracellular compartments largely depends on which fluid is administered (Macintosh 2011).

Crystalloids

Crystalloid solutions contain low-molecular-weight salts or sugars, which dissolve in water and freely pass between the intravascular space and the interstitial and intracellular spaces. For every 1L of 0.9% sodium chloride (normal saline) infused, 750mL (75%) leaves the intravascular space and enters the interstitial and intracellular spaces (Gouldon 2016). Crystalloids effectively replace lost intracellular and interstitial fluid. They also increase blood volume and blood pressure, but larger volumes will be necessary to achieve this compared with a colloid solution.

Crystalloid solutions include 0.9% sodium chloride, Ringer’s lactate and 5% dextrose (Frost 2015). The most commonly used crystalloid worldwide is 0.9% sodium chloride (Walter 2016). Balanced crystalloids such as Hartmann’s solution are also widely used (Semler and Kellum 2019) and there has been an increase in the use of crystalloids mixing low-concentration sodium and dextrose for maintenance purposes, particularly in critical care (Hoorn 2017).

The benefits of crystalloids include their low cost and the fact that they have a relatively few side effects. However, as they easily travel into the interstitial and intracellular spaces, they may cause oedema (Coppola et al 2014). Furthermore, the overuse of crystalloids containing sodium chloride may cause hyperchloremic acidosis (Hoorn 2017).

Colloids

Colloids contain larger molecules than crystalloids. These molecules are unable to cross capillary membranes, so colloid solutions largely remain in the intravascular space (Macintosh 2011). As a consequence, smaller amounts of colloids are required to replenish intravascular fluid volume compared with crystalloids, but colloids are not effective in replacing lost intercellular and interstitial fluid.

Colloids include gelatins, dextrans and hydroxyethyl starch (HES). Compared with crystalloids, colloids are associated with an increased risk of complications – including anaphylaxis, renal failure and coagulopathy – and are more expensive (Frost 2015). In 2014, the licence to produce HES was suspended in the UK because of evidence suggesting that the risks of its administration outweighed the benefits (Frost 2015). Following a review by the European Medicines Agency, HES remains licensed, but its use has been reduced (Cohen 2018).

Crystalloids versus colloids

There has been considerable debate about which IV fluid to use, particularly in patients with serious illness or injury, and there is wide variation in practice (NICE 2017). Numerous studies, and several systematic reviews of the evidence, have been conducted to explore the relative risks and benefits of crystalloids and colloids. A Cochrane review by Perel et al (2013) found no evidence that resuscitation with colloids reduced the risk of death in patients with trauma, burns or surgery compared with crystalloids. They questioned whether the use of colloids was justified considering that they are not associated with an improvement in survival, and are considerably more expensive than crystalloids (Perel et al 2013). In their update of this Cochrane review, Lewis et al (2018) concluded that there is no apparent benefit of using a colloid rather than a crystalloid for fluid resuscitation.
Box 3. Signs and symptoms of dehydration, fluid overload and speed shock

**Dehydration**
- Weight loss
- Thirst
- Irritability, restlessness and possible confusion
- Diminished skin turgor
- Dry mouth and furled tongue
- Negative fluid balance (decreased fluid input compared with output)

**Fluid overload**
- Weight gain
- Positive fluid balance (decrease in fluid output compared with input)
-Bounding pulse, indicating a high cardiac output
- Raised central venous pressure
- Peripheral oedema
- Hoarse voice
- Dyspnoea, cyanosis and coughing because of pulmonary oedema

**Speed shock**
- Flushed face
- Headache and dizziness
- Chest congestion secondary to fluid accumulation
- Tachycardia and fall in blood pressure
- Syncope
- Shock
- Cardiovascular collapse
(Adapted from Weinstein and Hagle 2014)

References


Cohen D (2018) EMA calls for hydroxyethyl starch solutions to be taken off market. BMJ. 360, k225. doi: 10.1136/bmj.k225


Cohen D (2018) EMA calls for hydroxyethyl starch solutions to be taken off market. BMJ. 360, k225. doi: 10.1136/bmj.k225


Intravenous fluid therapy
TEST YOUR KNOWLEDGE BY COMPLETING THIS MULTIPLE-CHOICE QUIZ

1. Which of the following elements of the renin-angiotensin-aldosterone system plays an important role in potassium regulation?
   a) Renin  
   b) Angiotensin  
   c) Aldosterone  
   d) Angiotensin-converting enzyme

2. Which of the following is a critical function of body fluid?
   a) Adjusting potassium levels  
   b) Maintaining acid-base balance  
   c) Replacing lost fluid  
   d) Regulating emotional responses

3. Where in the body would you find blood plasma?
   a) In the intravascular compartment of cells  
   b) In the interstitial compartment of cells  
   c) In the intracellular compartment  
   d) Both in the intracellular and extracellular compartment

4. Which of the following is a potential source of insensible fluid loss?
   a) Urination  
   b) Wound and gastric drainage  
   c) Blood loss  
   d) Breathing

5. Which of the following is not a parameter of the National Early Warning Score 2?
   a) Temperature  
   b) Pulse rate  
   c) Urine output  
   d) Level of consciousness

6. Which of the following is not one of the '5Rs' of intravenous fluid therapy?
   a) Referral  
   b) Redistribution  
   c) Reassessment  
   d) Replacement

7. What is the difference between crystalloids and colloids in terms of how they affect fluid distribution in the body?
   a) Crystalloids largely remain in the intravascular space, whereas colloids mostly pass into the interstitial and intracellular space  
   b) Crystalloids mostly pass into the interstitial and intracellular space within hours of infusion, whereas colloids largely remain in the intravascular space  
   c) There is no difference between crystalloids and colloids  
   d) Colloids leave the intravascular space more quickly than crystalloids

8. Which of the following is a possible side effect of the overuse of certain crystalloids?
   a) Coagulopathy  
   b) Hyperchloraemic acidosis  
   c) Anaphylaxis  
   d) Renal failure

9. What is the recommended fluid for initial intravenous fluid therapy?
   a) A crystalloid solution  
   b) A colloid solution  
   c) Human albumin  
   d) A mix of blood products

10. Which of the following is a sign of fluid overload?
    a) Diminished skin turgor  
    b) Flushed face  
    c) Headache and dizziness  
    d) Weight gain

How to complete this quiz
This multiple-choice quiz will help you to test your knowledge. It comprises ten questions that are broadly linked to the CPD article. There is one correct answer to each question.

» You can test your subject knowledge by attempting the questions before reading the article, and then go back over them to see if you would answer any differently.

» You might like to read the article before trying the questions.

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Further multiple-choice quizzes are available at rcni.com/cpd/test-your-knowledge

This multiple-choice quiz was compiled by Anne-Claire Bouzanne

The answers to this multiple-choice quiz are:

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