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The importance of fluid balance in clinical practice

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Summary

This article reviews the physiology that underpins normal fluid balance and discusses how fluid balance can be affected by illness. Clinical assessment of hydration and the importance of fluid balance record keeping are explained. Recommendations are made to improve fluid balance management in clinical practice and the professional importance of record keeping is highlighted.

Authors

Katie Scales is consultant nurse, Critical Care and Julie Pilsworth is sister, Critical Care Outreach, Imperial College Healthcare NHS Trust, Charing Cross Hospital, London.
Email: katie.scales@imperial.nhs.uk

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Aims and intended learning outcomes

This article aims to improve nurses' understanding of the normal mechanisms that control fluid balance and how fluid balance is affected by illness. A comprehensive hydration assessment is described and the importance of accurate fluid balance records is explained. Recommendations are made to improve the clinical management of fluid balance. After reading this article and completing the Time out activities you should be able to:

- Discuss the normal physiology of body water, including fluid compartments and the movement of water and electrolytes between compartments, normal fluid balance and maintenance of blood volume.
- Explain how illness can affect fluid balance and identify patients who will be vulnerable to disturbance of their fluid balance.
- Complete a comprehensive hydration assessment.
- Complete a fluid balance chart accurately, recognising when fluid intake or urine output is abnormal, and formulate a plan to resolve this.
- Reflect on your practice, identifying areas for development in relation to fluid balance documentation and demonstrating insight into the professional importance of fluid balance records.

Introduction

Maintenance of an adequate fluid balance is vital to health. Inadequate fluid intake or excessive fluid loss can lead to dehydration, which in turn can affect cardiac and renal function and electrolyte management. Inadequate urine production can lead to volume overload, renal failure and electrolyte toxicity. Attention to fluid intake and output, and careful completion of fluid balance charts, are important elements of nursing practice. Poor fluid balance management and poor record keeping have been identified as contributing factors to the poor outcome of some acutely unwell hospital patients (National Confidential Enquiry into Perioperative Deaths (NCEPOD) 1999, Healthcare Commission 2006, National Institute for Health and Clinical Excellence (NICE) 2007, National Patient Safety Agency (NPSA) 2007).

Body water

Approximately 60% of the human body is water (Berne *et al* 2005). Individual body water varies with age and with the amount of adipose tissue (fat) stored in the body. As the amount of adipose tissue increases, the percentage of body water falls. Women tend to store more adipose tissue than men and a female's body weight is approximately 55% water. A newborn infant's body weight is approximately 75% water and this percentage declines steadily until the age of one year when body water makes up 60% of body weight, the same as an adult (Berne *et al* 2005).

Most of the water is found inside the cells and is called intracellular fluid. However, one third of the water is outside the cells and is called extracellular fluid (Guyton and Hall 2005). Water is distributed in the body in fluid compartments. The intracellular fluid compartment and the extracellular fluid compartment are separated by the cell membrane. The intracellular fluid compartment is the largest compartment and holds two thirds of the total body water (Table 1). Body water contains many dissolved chemicals called electrolytes, for example sodium (Na^+), potassium (K^+), chloride (Cl^-), bicarbonate (HCO_3^-), calcium (Ca^{++}) and magnesium (Mg^{++}). The distribution of electrolytes varies between the fluid compartments and the number of positively charged electrolytes is balanced by the number of negatively charged electrolytes (Table 2).

The extracellular fluid compartment is divided into the vascular compartment (blood vessels) and the interstitial space (the gaps between the cells). The interstitial space contains interstitial fluid and the vascular compartment contains plasma, the water component of blood. The capillary wall separates the blood from the interstitial fluid.

Time out 1

How many litres of water does the average human body contain? Name the fluid compartments within the body. How much water is stored in each compartment?

The capillary wall is a semi-permeable membrane that is permeable to most molecules in the plasma except plasma proteins and red blood cells, which are too large to move through the capillary wall (Guyton and Hall 2005). The concentration of electrolytes on either side of the capillary wall is an important factor in the movement of electrolytes between the blood and the interstitial fluid. Electrolytes move by diffusion from an area of high concentration to an area of low concentration. This is known as the concentration gradient. Electrolytes can move rapidly over short distances. The steeper the concentration gradient the faster the molecule will move.

Water moves across semi-permeable membranes, in this case the capillary wall, by the process of osmosis. Osmosis causes water to move from an area of low concentration of solutes to an area of high concentration of

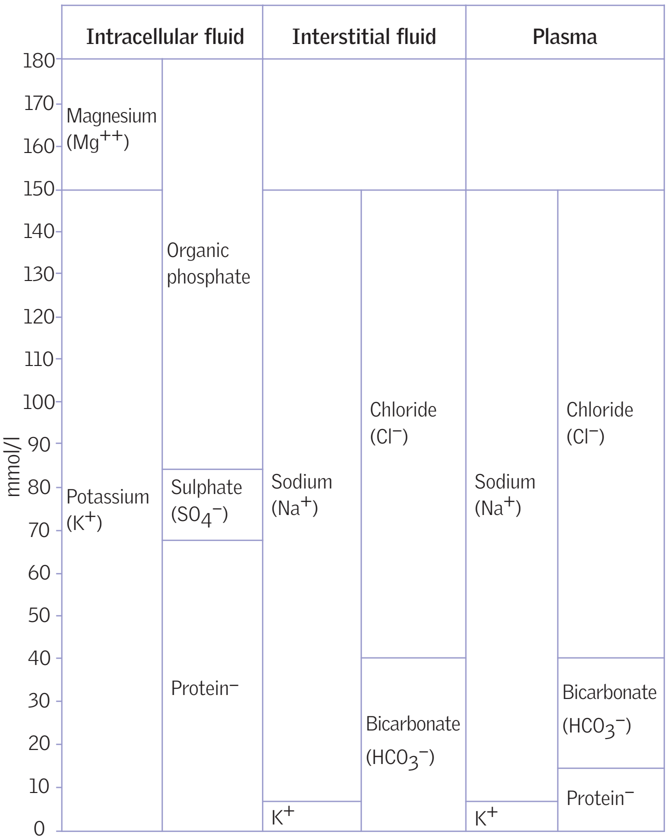
TABLE 1

Fluid compartments

Total body water 45 litres		
Extracellular fluid compartment		Intracellular fluid compartment
Vascular compartment	Interstitial compartment	30 litres of intracellular water
3 litres of plasma	12 litres of interstitial water	

TABLE 2

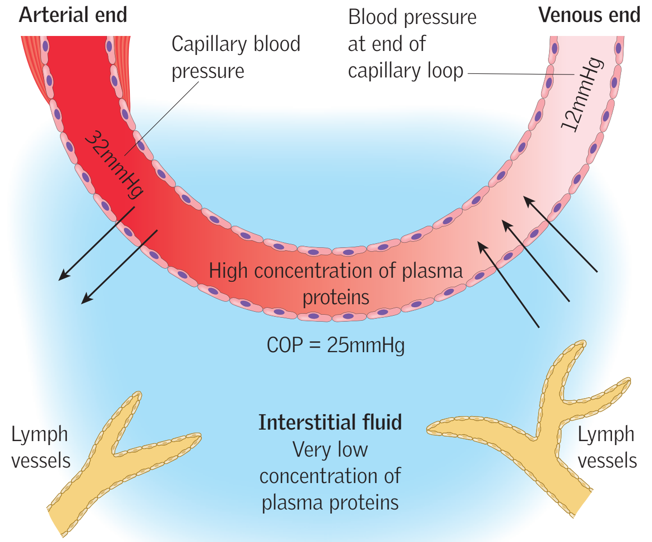
Electrolytes within the fluid compartments (simplified)



Interstitial fluid and plasma have similar constituents. Note the protein in the plasma to maintain colloid osmotic pressure. Sodium is the greatest extracellular electrolyte and potassium is the greatest intracellular electrolyte.

FIGURE 1

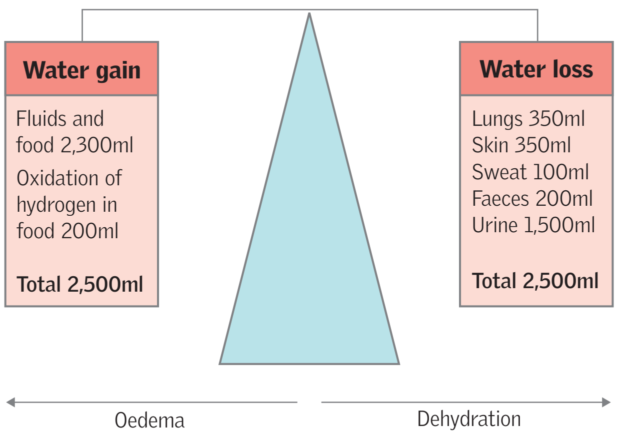
Systemic capillary loop



(COP = Colloid oncotic pressure)
At the arterial end, blood pressure is greater than COP and fluid is pushed out by hydrostatic pressure.
At the venous end, COP is greater than hydrostatic pressure and fluid is drawn in by osmosis.
Excess fluid or protein is absorbed by the lymphatic system.

FIGURE 2

Water balance



solutes (Berne *et al* 2005). Water moves freely between the intravascular and interstitial fluid compartments. The forces that determine water movement are hydrostatic pressure and osmotic pressure (Berne *et al* 2005). Hydrostatic pressure is created by the pumping action of the heart and the effects of gravity on the blood within the blood vessels. Osmotic pressure is generated by molecules in solution (Berne *et al* 2005). Osmotic pressure created by protein molecules is called colloid oncotic pressure; osmotic pressure created by electrolytes is called crystalloid osmotic pressure. Because blood contains more protein than interstitial fluid, the colloid oncotic pressure of blood is greater than the colloid oncotic pressure of interstitial fluid (Guyton and Hall 2005). Blood and interstitial fluid contain similar quantities of electrolytes and so the crystalloid osmotic pressure between the two compartments is similar. In health the colloid oncotic pressure generated by the high protein level of the blood draws water out of the interstitial space and into the blood by osmosis and prevents the formation of tissue oedema. The interstitial fluid maintains the blood volume and therefore the blood pressure. Figure 1 shows the forces at work in the systemic capillary loop. Plasma proteins include albumin, globulins and clotting proteins. Albumin is present in the greatest quantity. If patients are unable to manufacture albumin, for example in malnutrition or liver disease, or if albumin losses are high, for example in sepsis, burns or nephrotic syndrome, they will develop generalised oedema (Guyton and Hall 2005).

Time out 2

Explain the mechanisms by which water and electrolytes move between the blood and the interstitial space.

Fluid balance in health

On a day-to-day basis most people maintain a stable body weight and so it can be assumed that body water is also stable (Large 2005). Water intake should be balanced by water loss. Water is obtained from fluid and food in the diet, and water is lost mainly in urine but also through losses that are harder to measure, for example evaporation through the skin and the respiratory tract. This is termed insensible loss because the individual is unaware that it is happening (Berne *et al* 2005). Water is also lost in faeces. Figure 2 shows the normal balance of water intake and output.

Additional water can be lost through the production of sweat. The amount of sweat produced can increase dramatically during exercise and in hot weather (Table 3) and dehydration would occur if losses were not replaced through activation of the thirst mechanism (Guyton and Hall 2005). Water lost through faeces, sweat and evaporation cannot be regulated by the body and is a response to diet, illness or the environment. Water lost through the kidneys is highly regulated to ensure that the body's water balance remains stable (Berne *et al* 2005). If water losses increase or if water intake is reduced, the kidneys will conserve water by producing small volumes of highly concentrated urine. When water intake is high the kidneys produce large quantities of dilute urine.

In a healthy person, the amount of water taken in and the amount of water lost is usually in balance (Figure 2). If intake is greater than output a positive water balance occurs, if output is greater than intake a negative water balance occurs. A fluid balance chart is required to monitor a patient's fluid status. This is particularly important in acutely unwell patients (NCEPOD 1999, Healthcare Commission 2006, NICE 2007, NPSA 2007).

Fluid balance and illness

Normal fluid balance can be disrupted by illness. In health when individuals feel thirsty they drink. Patients are often unable to do this because they have less control over their environment and rely on health professionals to provide adequate fluids. When patients become ill they often lose their appetites. Dehydration is caused by lack of food and water. Physical problems such as vomiting, bowel disorders, exhaustion, frailty or unconsciousness all prevent a normal oral intake, while mental health problems often result in personal neglect. Without supplementary fluids dehydration will occur (Large 2005). Accurate assessment of hydration and the administration of prescribed fluids are essential to prevent dehydration. Fluid balance charts are an important part of hydration monitoring and the use of a 24-hour summary chart allows health professionals to monitor fluid trends over several days (NCEPOD 1999).

Hospital patients are at risk of increased water loss through a range of common mechanisms. The use of loose-fitting gowns increases skin exposure, which increases water evaporation from the skin. Infection causes pyrexia and sweating, which can cause excessive water loss (Table 3). Fever increases cell metabolism, which increases carbon dioxide production. In response the respiratory rate rises and more water vapour is lost from the lungs (Guyton and Hall 2005). Diarrhoea, vomiting and nasogastric drainage all increase water loss. Polyuria will cause dehydration unless fluid intake can be increased and is usually caused by hyperglycaemia, diabetes mellitus, a renal insult or overuse of diuretics (Large 2005). Polyuria, vomiting, nasogastric drainage and diarrhoea cause electrolyte disturbance as well as dehydration. Patients often experience reduced fluid intake at the same time as increased fluid loss, which can result in severe dehydration.

TABLE 3

Effect of hot weather and exercise on water loss in adults (ml/day)

Water loss	Normal temperature	Hot weather	Prolonged physical exercise
Insensible loss:			
Lungs	350ml	250ml	650ml
Skin	350ml	350ml	350ml
Sweat	100ml	1,400ml	5,000ml
Faeces	200ml	200ml	200ml
Urine	1,500ml	1,200ml	500ml
Total fluid loss	2,500ml	3,400ml	6,700ml
Water intake required to maintain water balance	2,500ml	3,400ml	6,700ml

(Berne *et al* 2005)

Dehydration causes the blood compartment to become more concentrated and water is drawn into the blood from the interstitial space by osmosis to maintain blood volume and blood pressure (Large 2005). The kidneys will produce concentrated urine in an attempt to conserve water. If dehydration persists the interstitial space will become dehydrated as fluid continues to be drawn into the blood to sustain the blood volume. This is a compensatory mechanism and while interstitial water is available to move across to the blood compartment, clinical observations of blood pressure and pulse may appear relatively normal. Once the interstitial space becomes dehydrated, decompensation will occur and vital signs will be affected. Low blood pressure, tachycardia, weak 'thready' pulse, cool peripheries (hands and feet) and oliguria are the classic signs of hypovolaemia (Large 2005). It is important to remember that these are late signs and the body will already be in a negative balance of several litres.

Overhydration, or an excess of body water, is less common than dehydration. Overhydration is usually iatrogenic and is more common in patients with heart failure, renal impairment and liver disease (Large 2005). Oedema is seen when the interstitial fluid volume is abnormally high. Oedema is not always caused by fluid overload and may be caused by a low colloid oncotic pressure from hypoalbuminaemia. In this situation the blood does not have enough colloid oncotic pressure to draw tissue water back into the vascular compartment. Oedema can occur at the same time as intravascular hypovolaemia (Oh *et al* 2003); the lower the albumin level the harder it is to maintain the blood volume.

Time out 3

Consider the patients in your clinical area. Do any of them have generalised oedema? Check their blood chemistry and determine their albumin level. How does the patient's albumin level compare with the normal level? Do you understand the mechanism that has caused the oedema? If not read the physiology section again and make notes describing how oedema occurs.

If the kidneys fail and are unable to excrete enough water, fluid overload may occur. Renal failure can be acute or chronic. Acute renal failure is reversible and inadequate renal perfusion from hypotension or hypovolaemia is the most common cause of acute renal failure (Large 2005). Chronic renal failure is irreversible and dialysis is required when the patient becomes symptomatic of volume overload or electrolyte toxicity.

Heart failure results in poor cardiac output, which in turn reduces perfusion to the kidneys. When kidney perfusion falls, urine production is reduced, causing further volume overload which can become a progressively destructive cycle for patients with heart failure. Many of these patients will require diuretic therapy to maintain a normal fluid balance. Patients with liver disease usually have a low albumin, which causes oedema.

Assessing hydration

Assessment of hydration has three main elements: clinical assessment, review of fluid balance charts and review of blood chemistry.

Clinical assessment The first part of the physical assessment is to ask patients if they feel thirsty, as thirst is the first clinical indicator of dehydration (Epstein *et al* 2004). Dehydration causes the osmolarity of the blood to increase and this is detected by osmoreceptors in the hypothalamus. The hypothalamus will evoke a sense of thirst and individuals will increase their oral intake (Guyton and Hall 2005). This is only effective if the person has the ability to control their intake. When patients are confused, unable to feed themselves or have an altered level of consciousness, it is nurses' responsibility to ensure that the patient is hydrated adequately (NCEPOD 1999). Dehydration causes the mucous membranes to become dry and assessment of the mouth and tongue is a useful part of the hydration assessment.

When patients become dehydrated their observations begin to change. As intravascular volume decreases, the blood pressure falls and the heart works harder to increase cardiac output, by increasing the heart rate (Large 2005). When blood pressure is low, patients may complain of feeling light-headed or dizzy, especially when standing. These are symptoms of postural hypotension.

The pulse should be taken manually as this provides important clinical information. The nurse should assess the strength of the pulse (pulse volume), rate and regularity. Is the pulse strong and bounding, weak and thready, or normal? A weak, thready, rapid pulse may indicate dehydration. While feeling the pulse the patient's skin temperature and texture should be assessed. Is the skin dry, cold and clammy, hot and sweaty, or normal? Patients who are dehydrated usually develop cool peripheries. The more severe the dehydration, the further up the limb the coolness will extend as vasoconstriction occurs to preserve blood pressure.

Capillary refill time (CRT) is a measure of intravascular volume (Large 2005). CRT is assessed by holding the patient's hand at the same level as their heart and pressing on the pad of their middle finger for five seconds. The pressure is then released and the time measured until normal colour returns. Normal filling time should be less than two seconds (Resuscitation Council (UK) 2006). CRT can be misleading in patients with sepsis. Fever causes blood vessels to dilate peripherally to radiate heat and regulate body temperature, so CRT is often immediate in such patients.

The elasticity of the skin (tissue turgor) is an indicator of fluid status in most patients. Tissue turgor should be assessed over a bony area such as the hand or shin. Pinch the skin gently, hold it for a second and release it. The skin will fall back quickly if the patient is well hydrated (Epstein *et al* 2004). Dehydrated patients have loose, inelastic skin that remains raised and slowly returns to normal. Tissue turgor is an unreliable indicator in older patients as skin elasticity is lost through the ageing process (Large 2005). It is difficult to pinch the skin if oedema is present. To assess for oedema apply fingertip pressure over a bony area for a few seconds and release. If the indentation does not disappear within 30 seconds pitting oedema is present (Large 2005).

The amount of urine produced varies according to fluid intake (Waugh and Grant 2006). Urine is usually amber in colour, and it is normal to produce about 1,500ml of urine every 24 hours (Waugh and Grant 2006). A 70kg individual in good health should pass around 70ml of urine per hour, which converts to approximately 1ml/kg/hr. If a patient is overhydrated the kidneys should increase water excretion to normalise the fluid balance and the urine will become pale and dilute.

If a patient is dehydrated the kidneys should conserve water and the urine will be reduced in volume and will become dark and concentrated. The specific gravity (SG) of urine can be measured to determine whether a patient's urine is dilute or concentrated. SG is a measure of the density of a liquid when compared to distilled water (Large 2005). The SG of distilled water is 1.000. As urine contains solutes the SG should be higher than water. The usual range for urine is 1.010-1.020 (Watson 2005). In polyuria the SG may be as low as 1.000 and in dehydration the SG may be as high as 1.030, the most concentrated possible. It should be noted that some drugs such as tuberculosis medication can change the colour of urine.

Daily weights also indicate a patient's fluid status. Weight will increase if a patient is becoming fluid overloaded and will decrease if dehydration occurs. Patients with cardiac failure can become fluid overloaded and it is important to weigh such patients daily.

Time out 4

Choose a patient in your clinical area who is not self-caring. Carry out a hydration assessment that includes all the elements listed above. Do you think the patient is appropriately hydrated? If not, is he or she dehydrated or overhydrated? Does the fluid balance chart help you to reach your decision?

Fluid balance charts The aim of a fluid balance chart is to keep an accurate record of a patient's fluid input and output and to identify any deficits. It is important to identify which patients require a fluid balance chart and to hand this over to staff between shifts. All staff should know which patients have fluid balance charts as this is important when giving out meals, emptying catheters or taking patients to the toilet.

The intake side of the chart requires careful measurement of all fluids including oral intake, enteral feeding, intravenous (IV) fluids, antibiotics and fluids given with medication. A chart that identifies the volume of different containers is helpful to ensure an accurate record of fluid intake. Patients who require assistance to eat and drink should be identified at patient handovers so that nursing staff are aware of their responsibilities and can ensure that the patient has an adequate intake. Nurses caring for patients with enteral or IV fluid regimens should ensure the fluids are running to the prescription, especially if the infusion is not regulated by an infusion pump.

The output side of the chart should record all measurable fluid losses resulting from: nasogastric tubes, drains, vomit, rectal tubes, colostomy drainage and urine. The patient's condition will dictate the frequency of urine measurement. Seriously ill patients and patients with reduced or excessive urine output will require more frequent assessment than stable patients. Patients who are acutely unwell require hourly urine measurements (Large 2005). Regular monitoring of urine output can indicate early changes in a patient's condition and early treatment can prevent deterioration (NPSA 2007). The minimum acceptable urine output for a patient with normal renal function is 0.5ml/kg/hr, and anything less than this should be reported. When renal function deteriorates urine production starts to decline. Urine production that stops suddenly is often caused by a mechanical problem and the nurse should check that the catheter is not kinked or blocked. If fluid losses cannot be measured, for example due to incontinence, each episode should be noted on the fluid chart.

Indications for commencing a fluid balance chart can be found in Box 1.

Time out 5

Reflect on the nursing management of patients in your clinical area. How do nurses assess whether a patient requires a fluid balance chart? If a patient has a fluid balance chart how is this communicated to the rest of the team? Are the charts handed over between shifts? Can you think of any areas for improvement?

Fluid balance charts are often badly maintained (NCEPOD 1999). Anderson (2003) believes that 'along with clinical examination, the fluid balance chart is the principal mechanism of assessment, but accuracy of fluid balance charts is variable'.

BOX 1

Indications for fluid balance monitoring

- Intravenous infusions.
- Subcutaneous infusions (hypodermoclysis).
- Enteral feeding.
- Nasogastric tubes for aspiration or drainage.
- Urinary catheterisation.
- Vomiting.
- Diarrhoea.
- Wound drains.
- Chest drains.
- Medical conditions that affect fluid balance, for example heart failure, renal failure, malnutrition or sepsis.

Reid *et al* (2004) investigated the completion of fluid balance charts and found that of 42 fluid balance charts audited on different wards, none was completed appropriately. Staff shortages, lack of training and lack of time were cited as the reasons for incomplete and inaccurate charts (Reid *et al* 2004).

Ward managers should ensure that all members of the nursing team have been trained to complete fluid balance charts accurately (NCEPOD 1999). Training should include completion of the charts, patient specific parameters including minimum or maximum intake, minimum acceptable urine output, target fluid balance and when to refer any issues with the charts to the nurse in charge.

Time out 6

Review ten fluid balance charts in your area. Have they been completed correctly? Is there a 24-hour summary chart to demonstrate the fluid balance trends over the past few days?

Review of blood chemistry Patients who are hypotensive or dehydrated are at risk of acute renal failure. The first sign may be a reduced urine output and if this is not treated the patient's blood chemistry will begin to change. Urea and creatinine are the two main electrolytes that indicate renal function. Increased levels of urea and creatinine are indicators of renal failure. If the urea rises but the creatinine remains normal this is usually an indicator of dehydration.

Professional importance of fluid balance record keeping

The Nursing and Midwifery Council (NMC) (2007) has issued clear guidance on the importance of record keeping and states that: 'Record keeping is an integral part of nursing practice… it is not an optional extra to be fitted in if circumstances allow.' Nurses are required to have the knowledge and competence to care for patients (NMC 2008), which includes understanding the indications for and importance of fluid balance charts. Fluid management should be accorded the same status as a drug prescription (NCEPOD 1999).

Patient records can be used in evidence by the courts, the Health Service Commissioner or locally to investigate a complaint; anything that refers to the care of the patient can be required as evidence (NMC 2007). In the recent investigation into an outbreak of *Clostridium difficile* the Healthcare Commission (2006) concluded that greater attention should be given to ensuring that patients do not become dehydrated and that good records are kept of intake and loss. The Healthcare Commission (2006) found that records for fluid balance were poor and that little attention had been paid to rehydration in patients with known diarrhoea.

The failure to detect acutely ill patients in hospital has been identified in a number of reports (Department of Health 2000, NICE 2007, NPSA 2007). The reports highlights to recognise, report and act on observations showing that a patient's condition is deteriorating. The NPSA (2007) highlighted the failure to measure basic observations of vital signs, lack of recognition of the importance of worsening vital signs and delay in responding to deteriorating vital signs as a key cause of mortality in acutely ill hospital patients. Recent NICE (2007) guidance requires employers to ensure that staff are trained to carry out observations and that they understand the clinical relevance of them. An annual audit is required to monitor compliance. NCEPOD (1999) recommended that staff were trained in fluid management.

Reid *et al* (2004) identified a lack of ownership in relation to fluid balance charts. It was unclear who was responsible for their completion. *The Code* (NMC 2008) is clear on this issue: the nurse caring for the patient is accountable for the care of the patient. If a task is delegated to an unregistered professional the nurse remains accountable for the appropriateness of the delegation, for ensuring that the person who does the work is able to do it and that adequate supervision is provided (NMC 2008). It is therefore the responsibility of the nurse caring for a patient to ensure that observations and fluids are recorded at a time interval that is appropriate for the patient's condition and that abnormal recordings are reported appropriately. Health records should demonstrate that assessments have been made and care given (Hutchinson and Sharples 2006). The NMC (2007) believes that good record keeping is the mark of a skilled and safe practitioner and that poor record keeping often highlights wider problems with an individual's practice.

Time out 7

Look again at the ten fluid balance charts from your area. Would these charts demonstrate that patients' fluid needs had been met? If there was an investigation would the documentation stand up to scrutiny?

Conclusion

The physiology that underpins fluid balance is an important aspect of nursing knowledge. Symptoms of dehydration only occur when the reserve of interstitial fluid is already depleted and the patient is in a negative balance of several litres. Altered vital signs and elevated renal chemistry are late signs of dehydration and careful attention to fluid balance charts could alert staff to fluid imbalances before symptoms occur. Fluid balance records are an essential part of patient care and the responsibility for maintaining fluid balance charts rests with nurses (NCEPOD 1999). Nurses should be able to perform a comprehensive hydration assessment to plan and deliver the care that patients require. Staff should be trained to complete fluid balance charts and should view the fluid balance chart with the same importance as a medication prescription (NCEPOD 1999). Fluid balance information should be handed over between shifts and nurses should report inadequate fluid intake or poor urine output promptly to prevent clinical deterioration. Recommendations for good practice are listed in Box 2 **NS**

BOX 2

Recommendations for practice

- Proactively assess which patients need a fluid balance chart.
- Measure fluid containers in use in your area and construct a reference chart.
- Maintain accurate fluid balance charts.
- Report adult fluid intake less than 2 litres in 24 hours and encourage intake.
- Report urine output less than 0.5ml/kg/hr.
- Carry out urinalysis daily for sick patients.
- Report signs of hypovolaemia such as tachycardia and hypotension.
- Ensure prescribed fluids are administered.
- Ensure that fluid balance is part of the bedside handover.
- Train staff to complete fluid balance charts correctly.
- Audit fluid balance charts to ensure good practice (Department of Health 2001).

Time out 8

Now that you have completed the article you might like to write a practice profile. Guidelines to help you are on page 60.

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