Supplemental material for 'Fluid management knowledge in hospital physicians: Greenshoots of improvement but still a cause for concern'. Leach RM et al

1. Study questionnaire and answers (see end)

The 'essential knowledge' questions are in red

The 'desirable knowledge' questions are in green

Questions in 'black' are considered to be at a level that a senior trainee (SpR and final year CMT) should be able to answer correctly

Questions in 'blue' are considered to be sufficiently 'difficult/complex' to be aimed at senior practitioners with an interest in fluid management (e.g. in intensive care consultants, renal physicians and gastroenterologists).

Intravenous Fluid Management Survey

Daily fluid assessment, prescription and administration are essential daily tasks on most medical and surgical wards. This brief survey if to assess your background knowledge relating to intravenous fluid therapy and to determine the amount of teaching/training you have received during your career-to-date on this important topic. Some questions will require factual knowledge, others will relate to typical clinical scenarios.

The survey is completely anonymous but we would appreciate if you could record your clinical grade, specialty and how much formal training/teaching have undertaken on intravenous fluid management and prescription as an undergraduate and as a postgraduate.

Grade:

Medical student __
FY1 and FY2 doctor __
Core Medical/Surgical Trainee __
Specialty Trainee __
Consultant __

Specialty

1. Medicine
   Acute Med __; Respiratory __; D and E __; Gastroenterology __; Cardiology __; Neurology __; Oncology __; Haematology __; Other specialty _____
2. Surgery __
3. Anaesthetics/ICU __

Training / Teaching

During your career to-date approximately how much formal training/teaching have you had/did you have as an undergraduate and as a postgraduate trainee (please tick approximate number of hours).

1. Undergraduate <2.5hrs__; <5hrs __; <10 hrs __; 10-20hrs __; 20-40hrs __; >40hrs __
2. Postgraduate <2.5hrs__; <5hrs __; <10 hrs __; 10-20hrs __; 20-40hrs __; >40hrs __

Confidence in fluid prescription

How confident are you about your fluid management and prescription skills on a scale of 1-10 (where 0 = no confidence and 10 = very confident). Circle appropriate number:

0 1 2 3 4 5 6 7 8 9 10

Adverse events

1. During your career have you had to manage the consequences of serious adverse events directly related to fluid prescription and administration (e.g. pulmonary oedema, hyponatraemia)?

Yes ___ No___ (If yes on approximately how may occasions <5 __; <10 __; 10-20 __; >20 __)

2. Were these adverse events formally reported and assessed (e.g. IR report with review)?

Always __; Usually__; Occasionally __; Rarely __; Never __

3. Has your fluid management ever resulted in a serious adverse event ?

Would rather not say __ ; Yes __; No __

(If yes were the event(s) reported? Would rather not say __; Yes __; No __)

PLEASE CIRCLE THE CORRECT ANSWER (e.g. b. 104)

What electrolytes are in commonly administered intravenous fluids?

1. How much sodium is in a litre of normal saline (in mmol)?

a. 74 b. 104 c.124 d. 134 e. 154

2. What is the osmolarity of normal saline (values in mosmol/l)?

a. 268 b. 278 c. 288 d. 298 e. 308

3. How much sodium is in a litre of Gelofusine (colloid) solution (in mmol/l)

a. 34 b. 74 c. 104 d. 134 e. 154

4. What is the composition of Hartmanns solution (values in mmol/l)

a. Na^+ 154 / K^+ 3.5 / Cl^- 154 / HCO_3 24
b. Na^+ 131 / K^+ 5.4 / Cl^- 112 / HCO_3 29
c. Na^+ 74 / K^+ 4.0 / Cl^- 74 / HCO_3 29
d. Na^+ 135 / K^+ 3.0 / Cl^- 125 / HCO_3 30
e. Na^+ 128 / K^+ 4.0 / Cl^- 100 / HCO_3 24

What are the normal daily fluid + electrolyte requirements?

5. How much sodium does a normal (70kg) person require daily (in mmol)?

a. 10-60 b. 70-120 c. 130-180 d. 190-240 e. 250-300

6. How much water intake does a normal person <70 years old (in normal UK environmental conditions) need to replace total daily losses (in mls/kg/day)

a. ~20 b. ~25 c. ~30 d. ~35 e. ~40

How are solutes and electrolytes excreted?

7. What is the maximum urine concentration that can be generated by normal kidneys (mOsm/L)?

a. ~600 b. ~1200 c.~1800 d. ~2400 e. ~3000

8. What is the normal daily excretion of urinary solute (mOsmol) for a 70kg man.

a. 100-300 b. 300-500 c. 600-800 d. 1000-1200 e. 1200-1400

What are the basics of fluid and electrolyte physiology in the human body

9. In a 70kg man, water comprises what proportion (%) of total body weight (or litres of water)?

a. 40% (28L) b. 45% (32L) c. 50% (35L) d. 60% (42L) e. 70% (49L)

10. What is the normal chloride concentration in serum (mmol)

a. 86-96 b. 96-106 c. 106-116 d. 116-126 e. 126-136

11. What is the normal electrolyte composition of intracellular fluid (values in mmol/l)?

a. Na^+ 10-15 / K^+ 150-160 / Cl^- 105-110 / PO_4 5-10
b. Na^+ 135-145 / K^+ 2.5-5.0 / Cl^- 105-115 / HCO_3 24-34
c. Na^+ 135-145 / K^+ 2.5-5.0 / Cl^- 1-5 / PO_4 105-110
d. Na^+ 5-10 / K^+ 150-160 / Cl^- 1-5 / PO_4 100-110
e. Na^+ 5-10 / K^+ 150-160 / Cl^- 100-110 / HCO_3 24-34

12. A equilibrated fall in serum K+ of 0.5mmol/L represents a total intracellacellular K+ loss (in mmol) of approximately:

a. 50 b. 100 c. 200 d. 400 e. 800

Volumes of distribution and metabolic consequences of intravenous fluid administration?

13. Four hours after administration of 1L of normal saline to a well 70kg man, how much would you expect to remain in the intravascular compartment (in mls)?

a. ~70mls b. ~125mls c. ~175mls d. ~225mls e. ~300mls

14. Which of the following may occur after excessive normal saline (0.9% saline) administration?

a. Hyperchloraemic Metabolic Acidosis
b. Hypernatraemic Metabolic Alkalosis
c. Hypochloraemic Metabolic Alkalosis
d. Hyponatraemic Metabolic Acidosis
e. Hyperkalaemic Metabolic Alkolosis

How is the intravascular volume maintained in health and during pathophysiological insults?

15. Albumin accounts for what percentage of plasma osmotic pressure in normal health

a. 20-35% b. 35-50% c. 50-65% d. 65-80% e. 80-95%

16. How much water is bound to 1 gram of albumin (in mls)?

a. ~6 b. ~12 c. ~18 d. ~24 e. ~30

17. A clinically stable, euvolaemic 75 year old man (60kg) with mild renal and cardiac impairment is unable to drink (i.e. take oral fluids) due to an impaired swallow reflex following a hypothalamic stroke. He requires his daily intravenous fluid and electrolyte prescription. Which of the following fluid maintenance regimes would be most suitable?

a. 2L normal (0.9%) saline with 20mmol KCL added to each litre bag of normal saline.
b. 3L dextrose/saline with 40mmol KCl added to each litre bag
c. 1L normal (0.9%) saline and 2L 5% dextrose with 40mmol KCl added to each litre bag of fluid
d. 2L of 0.18% saline with 20mmol KCl added to each litre bag of 0.18% saline
e. 2L 5% dextrose with 20mmol KCl added to each litre bag of 5% dextrose

18. Three days after major bowel surgery, a 45 year old man (70kg) has 2L nasogastric tube drainage due to a severe paralytic ileus. His pulse is 90 beats per minute (sinus rhythm) and blood pressure 110/60mmHg. Routine blood tests reveal hypokalaemia (K+ 2.9mmol/L), a sodium concentration of 129mmol/L and urea of 18mmol/L. A blood gas shows an alkalosis with a pH 7.56. He is currently on the high dependency unit with central access. Which of the following fluid regimes would be most appropriate during the next 24hours?

a. 3L Normal (0.9%) saline and 1L 10% glucose with 20-40mmol KCl added to each litre bag.
b. 4L 0.18% saline with 20-40mmol KCl added to each litre bag.
c. 3L 5% dextrose with 20-40mmol KCl added to each litre bag.
d. 1L Hartmanns solution and 3L of 5% dextrose with 20-40mmol KCl added to each bag.
e. 2L Normal (0.9%) saline with 20-40mmol KCl added to each litre bag.

19. An 18 year old college girl was admitted to A+E with meningiococcal septicaemia. She was febrile, obtunded and shocked with a blood pressure of 90/50mmHg at admission. Antibiotic therapy was initiated and following initial fluid resuscitation (2L) her blood pressure improved to 120/80mmHg but blood gases showed a metabolic acidosis (pH 7.29) with significant base deficit. On transfer to ICU she was requiring an intravenous fluid at a rate of 175mls/hr to maintain her blood pressure. What would be the most suitable resuscitation fluid at this stage?

a. Gelofusin
b. Hartmann's solution
c. Hydroxyethyl starch 6%
d. Normal saline
e. Blood

20. Seven days after a road traffic accident (RTA) with long bone fractures, associated tissue contusion and mild secondary wound sepsis, a 36 year old woman is hypotensive (100/50mmHg), with poor urine output (20-25mls/hr) and has widespread severe tissue oedema. At admission and over the subsequent 6 days she received large quantities of crystalloid resuscitation fluid (>15L). On this occasion her haemoglobin was 8.5g/dl, serum sodium 129mmol/L, albumin 15g/dl, CRP 35mg/L and slightly impaired renal function with a creatinine of 124µmol/L. Urinary sodium was <5mmol/L. Diuretics did not improved urine output and caused further hypotension after a brief diuresis. What was the main cause of her oliguria?

a. Hypotensive renal impairment.
b. Intravascular fluid volume depletion.
c. Renal vasoconstriction due to hyperchloraemia
d. Cardiac failure due to myocardial contusion
e. Diuretic-induced interstital nephritis

Having completed the questionnaire how confident are you about your fluid prescription?
How confident are you about your fluid management and prescription skills on a scale of 1-10 (where 0 = no confidence and 10 = very confident). Circle appropriate number:

0 1 2 3 4 5 6 7 8 9 10

Answers

1. e
2. e
3. e
4. b
5. b
   Note: Daily electrolyte requirements 1 mmol/kg/day for Na^+, K^+, Cl^- as per NICE CG174 although probably slightly higher for Na^+ at 1.5mmol/kg/day under most circumstances
6. c
   Note: Daily water requirement 30mls/kg/day (reduced to 25mls/kg/day for older, frail and comorbidities) as per NICE CG174
7. b
   Note: Maximum urine concentration 1200 mOsm/L but falls to about 1000mOsm/L after 60 years old
8. c
   Note: During a normal day solute excretion comprises ~400 mOsmol/day urea waste, with 200 mOsmol/day Na^+ and Cl^- ions loss (i.e. 100mmol NaCl) and 100 mOsmol/day of K^+ and Cl^- ions loss (i.e. 50mmol KCl). Consequently total solute loss is ~700 mOsmol/day
9. d
10. b
11. d
12. c
13. c
    Note: 0.9% saline redistributes mainly to the extracellular compartment which is about 17L. There are 3L of plasma and so 3/17 x 1000 = 176mls will remain in the vascular compartment
14. a
15. d
16. c
    Note albumin binds about 18mls water/gm (colloid pressure). There are about 120gms of albumin in the intravascular compartment (3L plasma containing 40gm/L). The intravascular albumin therefore binds 120x18=2.16L of fluid into the intravascular compartment (the remainder of the plasma water is bound to haemoglobin and a little to the globulins).
17. d
    Note: this patient requires a simple maintenance regimen (algorithm 3 in NICE CG174). Patient weighs 60kg and ideally needs 1.5-1.8L water and 60mmol Na^+ and K^+. The best fit for the fluid regimens listed is 2L 0.18% saline (30mmol/L Na^+) with 20mmol KCl added to each bag
18. a
    Note: This is a complex 'Replacement and Redistribution' regimen (algorithm 4 in NICE CG174). The 2L nasogastric (NG) output represents a high Na^+, H^+ and Cl^- loss requiring replacement with Na^+ containing fluid. The hypokalaemic metabolic alkalosis is due to renal excretion of K^+ in exchange for H^+ ions (H^+/K^+ exchanger) to correct for the loss of H^+ ions in the NG fluid. Option a is the best answer as the patient requires 4L of fluid (2L normal requirement plus 2L of NG fluid) with high levels of Na^+ and K^+ replacement. The 10% glucose provides the 50–100 g/day of glucose required to limit starvation ketosis.
19. b
    Note: NICE CG 174 (algorithm 2) recommends the use of a physiologically balanced crystalloid solutions for high volume resuscitations (to reduce iatrogenic metabolic acidosis due to hyperchloraemia) as in this case of a young patient with meningiococcal septicaemia.
20. b
    Note: A difficult physiological 'Replacement and Redistribution' case (algorithm 4 in NICE CG174). The patient is oedematous (15L positive fluid balance), 'inflammatory' due to the recent trauma (CRP 35mg/L), urine output is low with a low urinary sodium (<5mmol/L Na^+) suggesting fluid retention, the serum sodium is low (Na^+ 129) due to renal water retention, the blood pressure and albumin levels are low consistent with failure to maintain intravascular volume due to increased vessel permeability and reduced colloid oncotic pressure. This is

confirmed by the poor response to diuretic therapy which results in a very limited diuretic response and drops the BP further.

2. Supplementary figure

Figure 1. Confidence in fluid management before and after completing the multiple choice questions