



Fluid and electrolyte balance—establishing the knowledge base of Foundation Year One doctors

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Abstract

Background Fluid and electrolyte management for hospital inpatients has been identified by multiple reports to be suboptimal, with delegation of this task to the most junior members of a medical team, Foundation Year One (FY1) doctors, also known as interns or house officers, being identified as a contributing factor.

Methods An online survey was distributed nationally via social media to FY1 doctors between 21st August 2018 and 19th September 2018. Questions focused around cohort characteristics, team behaviours around fluid and electrolyte prescribing, as well as teaching and knowledge.

Results Two hundred eighty-six doctors participated. 67.13% knew the daily water requirement of a healthy adult. 58.39 and 79.72% knew the daily requirements of potassium and sodium, respectively. 41.26 and 33.57% knew the potassium and sodium composition of Hartmann's solution (1 L), respectively, with only 31.12% of candidates knowing the correct sodium content of 1 L of normal saline 0.9%. FY1 doctors were the principle prescribers of fluid therapy (97.55%); senior house officers, registrars, and consultants were only actively involved in the process 51.75, 20.98, and 5.59% of the time, respectively. 30.77 and 23.43% of FY1s received guidelines and/or teaching on the topic within their firms or as part of their foundation teaching, respectively. At undergraduate level, 52.44% of doctors reported the teaching to be “neither poor or good,” “poor,” or “very poor.”

Conclusion The principle knowledge base underlying fluid and electrolyte management is still poorly understood by FY1 doctors, with poor teaching of the subject at both undergraduate and post-graduate level potentially contributing.

Keywords Electrolyte · Fluid · Foundation doctor · Intern · Medical education · Postgraduate medical education · Prescribing

Introduction

The 1999 NCEPOD [1] report identified an alarming issue with intravenous (IV) fluid infusions, with patient mortality being significantly affected by the administration of either too much or too little IV fluids. This was especially true for elderly patients, the highest subgroup of hospital inpatients today—and one which is growing. The NCEPOD authors identified a

number of reasons for this, including (i) a lack of proper pre- and post-operative evaluation and management of a patient's physiological state, (ii) insufficient multi-disciplinary input by senior medical professionals, and (iii) the need for better education of junior medical and nursing staff around the management of fluid and electrolyte requirements. During the same year, a striking article highlighting the prevalence of severe hyponatraemia post-orthopaedic surgery was also published in the BMJ [2]. Similar to the NCEPOD report, it highlighted (i) a lack of knowledge around the post-operative stress response, (ii) physiological post-operative hyponatraemia, (iii) impaired fluid and electrolyte homeostasis in the elderly, (iv) the complexities of the co-morbid patient, and (v) the impact of medications on fluid and electrolyte balance, e.g. thiazide diuretics. These studies triggered a number of audits and studies, which looked into the issue of improper fluid and electrolyte management in hospital patients. Most of these studies acknowledged the fact that the responsibility of fluid prescribing is often left to the most junior members of the team and

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investigated the knowledge base of Foundation Year One (FY1) doctors. In 2001, Lobo et al. [3] found that, although FY1s were responsible for prescribing fluids in 89% of instances, less than half were actually aware of the sodium content of 0.9% normal saline or the daily sodium requirement. To further this, in 2002, they carried out another audit, which showed not only that consultants did feel that FY1s were not adequately trained in the subject but also that FY1s themselves received very little training on fluid and electrolyte management [4]. Both those reports concluded that undergraduate and post-graduate education needed to improve in order to improve the morbidity and mortality related to inappropriate fluid administration. The National Institute of Clinical Excellence (NICE) has since published guidelines on *Intravenous Fluid Therapy in Adults in Hospitals* in 2013 [5]; moreover, even more audits and studies have since been published in an attempt to raise awareness around the issue [2, 5–13]. Our study therefore focused on ascertaining whether house officers are currently better equipped with the knowledge required to safely administer IV fluid therapy.

Methods

An online survey was distributed nationally via social media to FY1 doctors between 21st of August 2018 and 19th September 2018. Questions focused on cohort characteristics, team behaviours, as well as fluid and electrolyte teaching and knowledge. Our questions are in keeping with those asked by Lobo et al. [3] in 2001. This was done intentionally in an attempt to better assess any changes in FY1 knowledge and training (with respects to fluid and electrolyte balance) since 2001. The questionnaire is shown in Table 1.

References for the daily maintenance requirements of potassium (mmol/kg/day), sodium (mmol/kg/day), water (mL/kg/day), and the amount of potassium and sodium (mmol/L) in 1 L of Hartmann's solution, 0.9% N. saline, and 5% dextrose were derived from the 2013 NICE guidelines *Intravenous Fluid Therapy in Adults in Hospitals* [5]. References for the upper and lower limits of normal serum potassium and sodium (mmol/L) were derived from the 10th edition of the Oxford Handbook of Clinical Medicine [14]. Given the wide variability of values for the normal upper limit of serum potassium, we allowed all answers between 5.0 and 5.5 mmol/L [14, 15]

Values for the minimal (obligatory) 24-h volume (mL) essential to excrete the solute load were based on the 9th edition of Kumar and Clark's Clinical Medicine [16] as well as the range used by Lobo et al. [3]. Numerous sources [14, 17–19] were used to finalise the reference value for the desired urine output (in mL/h) in a healthy 70-kg man (with normal daily fluid intake).

For the question on how FY1s assess fluid status, we reviewed the literature available for methods used to assess fluid status in patients, as there is no current NICE guideline for a systematic approach. The article by Mohsenin [20] provided us with a starting point, as the authors had itemised assessment of fluid status in ITU patients into several useful categories. We then set out to develop our own criteria, which included relevant criteria for a ward based environment and was at a level suitable for an FY1 doctor.

Thirteen standardised criteria were developed (Table 6) and these included assessment of the central nervous system, cardiovascular system, respiratory system, integumentary system, abdominal system, observations including body temperature, assessment of urine output and formal review of fluid balance, weight and stool charts, nutritional aspects of the patients diet (nil by mouth, enteric feeding, or on TPN), interpretation of biochemical results, review of drug chart, subjective assessment of thirst, and a further criteria for "other methods."

It was not possible to calculate the response rate as the social media platform used, Facebook, did not provide information as to how many FY1 doctors had seen the survey; however, these 286 respondents are significantly more than the 100 in the previous study by Lobo et al., and represent 15 foundation schools.

Data was analysed using simple statistics on Microsoft Excel®.

Results

Study cohort characteristics

Two hundred eighty-six FY1 doctors from 15 different foundation schools participated in the survey. They carried out their undergraduate training in > 20 different universities. 60.14% were male and 39.86% female. Ninety-seven percent of participants were within 18 and 34 years of age. The majority of respondents were working in either a medical (47.9%) or surgical (41.61%) firm. Results are shown in Table 2.

Team behaviours

Results for team behaviours are shown in Table 3. 97.55% of FY1 doctors reported being the principal fluid prescribers on their teams. In 51.75, 20.98, and 5.59% of teams, the SHO, registrar, and consultant, respectively, also shared the responsibility.

54.55% of medical/surgical teams reviewed the fluid balance chart during the morning ward round, 9.09% reviewed it later during the day, and 45.8% did not regularly check the chart at all.

Only 30.77% of FY1s received guidelines and/or teaching on fluid and electrolytes when starting on their new firm.

Table 1 Fluid and electrolyte questionnaire**Table 1 - Fluid and Electrolyte Questionnaire****Q1. What is your age?**

10 to 24 25 to 34 35 to 44 45 to 54 55 to 64

Q2. What is your gender?

Female Male

Q3. Which Medical School did you attend? If you studied outside of the United Kingdom, please also write down the name of the country.**Q4. To which Foundation School are you current affiliated?****Q5. In which specialty are you currently working?**

Medicine (included all subspecialties) Surgery (include all subspecialties) General Practice Emergency Medicine
 Obstetrics and Gynaecology Paediatrics Psychiatry Anaesthetics Other (please specify)

Q6. Who is principally responsible for prescribing fluid and electrolytes on your firm? Please select all that apply.

FY1 SHO Registrar Consultant

Q7. How confident are you in your ability to prescribe fluid and electrolytes?

Very confident Reasonably confident Not confident

Q8. How would you rate the teaching on fluid and electrolytes you received in Medical School?

Very good Good Neither poor or good Poor Very Poor

Q9. Please comment on why you rate the teaching this way.**Q10. Have you received any guidelines and/or teaching on fluid and electrolytes since you began working on your firm?**

Yes No

Q11. Have you received any formal teaching about fluid prescribing during FY1? If yes, please state if induction, FY1 teaching, Ward Teaching or Other (please write which).

No I have not Yes I have (please specify)

Q12. When are the fluid balance charts checked on your current firm?

On the morning ward round Later Not regularly checked

Q13. What is the daily Potassium AND Sodium requirement of a healthy adult (maintenance)? (mmol/kg/d)

Potassium=

Sodium=

Q14. How much Potassium is in a 1L bag of Hartmann's Solution, 5% Dextrose and 0.9% N. Saline? (mmol.L)

Hartmann's Solution=

5% Dextrose=

N.Saline=

Q15. How much Sodium is in a 1L bag of Hartmann's Solution, 5% Dextrose and 0.9% N. Saline? (mmol.L)

Hartmann's Solution=

5% Dextrose=

N.Saline=

Q16. What is the daily maintenance water requirement of a healthy adult (assuming 70kg) (mls/kg/day)?**Q17. What are the normal lower and upper limits of serum Sodium? (mmol/L)**

Lower=

Upper=

Q18. What are the normal lower and upper limits of serum Potassium? (mmol/L)

Lower=

Upper=

Q19. What is:

-The minimal (obligatory) 24 hour urine volume (mls) essential to excrete the solute load?

-The desired urine output (in mls/hour) in a healthy 70kg man (with normal daily fluid intake)?

Q20. What parameters, on patient examination, do you look at when assessing the fluid status of a patient? Please list all.

Table 2 Study cohort characteristics

	All	Percentage
Survey respondents	286	
Gender		
Male	172	60.14%
Female	114	39.86%
Age breakdown		
18–24	158	55.24%
25–34	122	42.66%
35–44	5	1.75%
45–54	1	0.35%
55–64	0	0%
Medical schools		
Bart's	15	5.24%
Birmingham	19	6.64%
Cardiff	9	3.15%
Edinburgh	10	3.50%
Hull and Yorkshire	8	2.80%
Imperial	11	3.85%
King's College London	13	4.55%
Leeds	11	3.85%
Leicester	11	3.85%
Liverpool	12	4.20%
Manchester	20	6.99%
Newcastle	13	4.55%
Nottingham	10	3.50%
Oxford	17	5.94%
Sheffield	10	3.50%
Southampton	8	2.80%
St George's London	11	3.85%
UCL	17	5.94%
Warwick	9	3.15%
Other	52	18.18%
Foundation schools		
East Anglia	17	5.94%
Essex Bedford and Hertford	10	3.50%
Leicester Northamptonshire & Rutland	13	4.55%
North Central & East London	24	8.39%
North West London	18	6.29%
North West England	26	9.09%
Northern	16	5.59%
Oxford	15	5.24%
Scotland	24	8.39%
South Thames	19	6.64%
Trent	13	4.55%
Wales	11	3.85%
Wessex	13	4.55%
West Midlands	32	11.19%
Yorkshire & Humber	35	12.24%
Current specialty [†]		
Medicine	137	47.9%

Table 2 (continued)

	All	Percentage
Surgery	119	41.61%
Obs & gynae	4	1.4%
Paediatrics	4	1.4%
Emergency medicine	3	1.05%
Psychiatry	8	2.80%
Anaesthetics	8	2.80%
General practice	0	0
Intensive care	1	0.35
Rehabilitation	1	0.35

Fluid and electrolyte teaching

Results for fluid and electrolyte teaching are shown in Table 4. At undergraduate level, 47.55 and 22.72% of FY1 rated the quality of teaching on the topic as good/very good and poor/very poor, respectively.

At post-graduate level only 23.43% of FY1s received any formal teaching on the topic. These respondents reported receiving this teaching at induction, on the wards, in compulsory formal FY1 teaching lectures and via online SCRIPT [6] modules.

The majority of FY1s (69.23%) felt reasonably confident in their ability to prescribe fluid and electrolytes to patients, with 25.87% not feeling confident and 4.9% feeling very confident.

Fluid and electrolyte knowledge

The following results are all demonstrated in Table 5. The reference value used for the daily potassium and sodium requirements of a healthy adult (maintenance) was 1 mmol/kg/day [5]. Based on this, 58.39 and 20.28% of FY1s knew the correct answer for potassium and sodium, respectively.

A 1-L bag of Hartmann's solution contains 5 mmol/L of potassium [5] and 131 mmol/L of sodium [5]. 41.26 and 33.57% of FY1s, respectively, answered this question correctly.

A 1-L bag of 5% dextrose contains 0 mmol/L of potassium and sodium [5]. 89.16 and 80.42% of FY1s, respectively, answered this question correctly.

A 1-L bag of 0.9% N. saline contains 0 mmol/L of potassium [5] and 154 mmol/L of sodium [5]. 89.18 and 31.12% of FY1s, respectively, answered this question correctly.

As per NICE guidelines 2013, the daily maintenance water requirement of a healthy adult (assuming 70 kg) is 20–30 mL/kg/day. Only 32.87% of FY1s answered with a value that falls within this range.

The lower and upper limits of serum potassium are 3.5 [14] and 5.0 mmol/L [14], respectively. However, given the wide variability of values in the literature for the normal upper limit of serum potassium, we accepted any answer within the range

Table 3 Team behaviours

	All	Percentage
Survey respondents	286	
Principal fluid prescribers on your team		
FY1	279	97.55%
SHO	148	51.75%
Registrar	60	20.98%
Consultant	16	5.59%
Timing of fluid balance chart reviews		
Morning ward round	157	54.55%
Later	26	9.09%
Not regularly checked	131	45.8%
Received guidelines and/or teaching on fluid and electrolytes on current firm		
Teaching received	88	30.77%
No teaching received	198	69.23%

of 5.0–5.5 mmol/L [14, 15]. Based on this, 40.91 and 83.22% of FY1s, respectively, answered the question correctly.

The lower and upper limits of serum sodium are 135 [14] and 145 mmol/L [14], respectively. 74.13 and 71.33% of FY1s, respectively, answered the question correctly.

For the minimal (obligatory) 24-h urine volume essential to excrete the solute load, we accepted any answer between 500 and 750 mL [3, 16]. Only, 16.43% of FY1s answered within this range.

We used 0.5–1 mL/kg/h [14, 17–19] or 35–70 mL/h as reference for the desired urine output of a healthy 70-kg man with normal daily fluid intake. 49.10% of FY1s answered in accordance with our reference values.

Table 6 summarises the details of the criteria used to assess fluid status. Figures 1 and 2 summarise the results for Q20 in

Table 4 Fluid and electrolyte teaching

	All	Percentage
Survey respondents	286	
Rating of fluid & electrolyte teaching in medical school		
Very good	25	8.74%
Good	111	38.81%
Neither poor nor good	85	29.72%
Poor	55	19.23%
Very poor	10	3.5%
Confidence in ability to prescribe fluids and electrolytes		
Very confident	14	4.9%
Reasonably confident	198	69.23%
Not confident	74	25.87%
Received formal teaching on fluid and electrolytes as FY1		
Teaching received	67	23.43%
No teaching received	219	76.57%

Table 1, ‘What parameters, on patient examination, do you look at when assessing the fluid status of a patient?’.

Eighty-nine percent of respondents stated they would assess the integumentary system as part of the formal assessment of fluid status. This was the most common criteria amongst respondents. The second most common criterion was assessment of the cardiovascular system (84%); this was more common than assessment of the respiratory system (60%).

Seventy-seven of respondents stated they would check observations as part of their assessment. Medical school curricula teach students to perform an ABCDE assessment of a sick patient, to ensure that critical information is not missed when assessing these patients. Given that 23% of respondents are not checking observations, we would advocate institution of a similar methodology as it will be one well known to medical students and FY1 doctors alike.

Only 28% of respondents stated that they would carry out a formal assessment of the patient’s input and output by reviewing the fluid balance, weight, and stool charts. Only 12 respondents (4%) explicitly stated that they would assess for insensible losses by reviewing a patient’s body temperature.

Three respondents (1%) stated that they would check fontanelles in paediatric patients. One respondent (0.3%) stated that they would review the chest X-ray. This is particularly concerning, as all doctors should be checking a patient’s chest X-ray for signs of pulmonary oedema [16].

Whilst 2% of respondents stated they would review the drug chart as part of their assessment, no respondents would review the patient’s medical notes (past medical history and notes from the current admission) and then correlate this with the rest of their assessment. Again, this point is important because it would enable the doctor to understand the context of a presentation if they are not familiar with the patient—such as patient who appears to be short of breath on examination and has a background history of heart failure, which could point to potential diagnosis of pulmonary oedema.

Twenty-four respondents (8%) specified that they would take into consideration abdominal drains and stomas when assessing fluid status in patients. This suggests that there is an opportunity in the clinical years at medical school or in the early part of the FY1 teaching programme/induction for targeted training to improve this important area.

Two respondents (0.6%) did not include physical examination as part of their process of assessment.

Assessment of the central nervous system was also poorly represented with only 4% of respondents including it in their assessment.

Discussion

IV fluid prescribing has frequently been shown to be sub-optimal in emergency departments, acute admission units

Table 5 Fluid and electrolyte knowledge

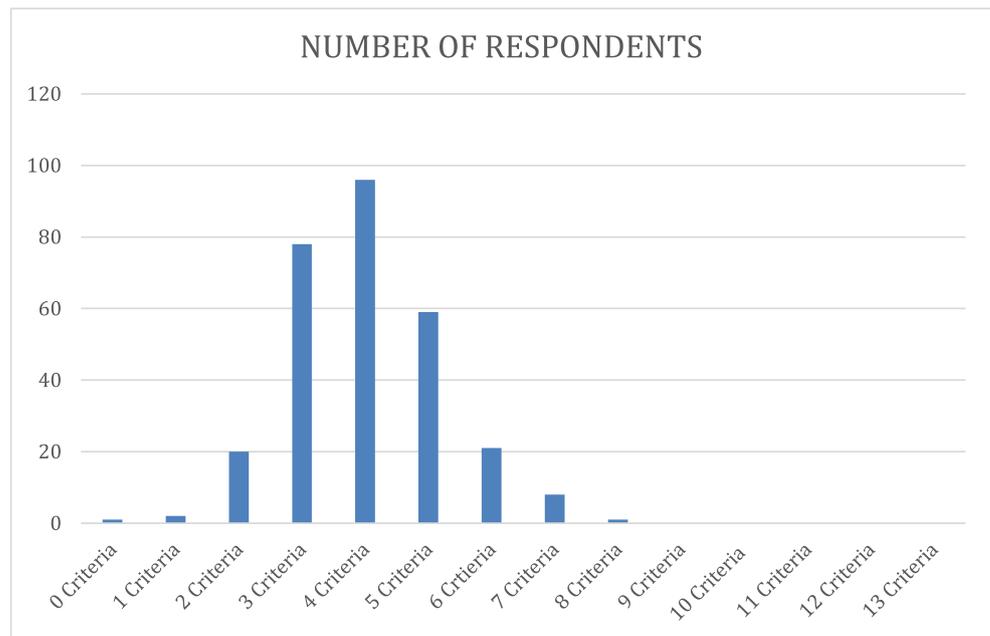
	All	Percentage
Survey respondents	286	
Daily potassium requirements (1 mmol/kg/day) [5]		
Correct	167	58.39%
False	119	41.61%
Daily sodium requirements (1 mmol/kg/day) [5]		
Correct	58	20.28%
False	228	79.72%
Potassium in 1-L bag of Hartmann's (5 mmol/L) [5]		
Correct	118	41.26%
False	168	58.74%
Potassium in 1-L bag of 5% dextrose (0 mmol/L) [5]		
Correct	255	89.16%
False	31	10.84%
Potassium in 1-L bag of 0.9% saline (0 mmol/L) [5]		
Correct	255	89.16%
False	31	10.84%
Sodium in 1-L bag of Hartmann's (131 mmol/L) [5]		
Correct	96	33.57%
False	190	66.43%
Sodium in 1-L bag of 5% dextrose (0 mmol/L) [5]		
Correct	230	80.42%
False	56	19.58%
Sodium in 1-L bag of 0.9% saline (154 mmol/L) [5]		
Correct	89	31.12%
False	197	68.88%
Daily maintenance water requirement of a healthy 70-kg man (20–30 mL/kg/day) [5]		
Correct	94	32.87%
False	192	67.13%
Normal upper limits of serum sodium (145 mmol/L) [14]		
Correct	204	71.33%
False	82	28.67%
Normal lower limits of serum sodium (135 mmol/L) [14]		
Correct	212	74.13%
False	74	25.87%
Normal upper limits of serum potassium (5.0–5.5 mmol/L) [14, 15]		
Correct	238	83.22%
False	48	16.78%
Normal lower limits of serum potassium (3.5 mmol/L) [14]		
Correct	117	40.91%
False	169	59.09%
Minimum 24-h urine volume to excrete solute load (500–750 mL) [3, 16]		
Correct	47	16.43%
False	239	83.57%
The desired urine output in a 70-kg man with normal daily fluid intake (0.5–1 ml/kg/h) [14, 16–18]		
Correct	129	45.10%
False	157	54.90%

Table 6 Fluid status assessment framework

#	Criteria	Details
1	CNS status	<ul style="list-style-type: none"> • Formal GCS scoring • Confusion • Drowsiness
2	CVS assessment	<ul style="list-style-type: none"> • JVP • Auscultation of heart (S3 gallop) • Peripheral oedema • Assessment of pulse character • Central and peripheral capillary refill time
3	Respiratory	<ul style="list-style-type: none"> • Auscultation of lungs (pulmonary oedema) • Clinical signs of respiratory distress
4	Integumentary	<ul style="list-style-type: none"> • Skin turgor • Mucous membranes • Skin warmth • Colour
5	Urine output	<ul style="list-style-type: none"> • Urine output (if no formal assessment of fluid balance) • Catheter
6	Formal assessment of input and output	<ul style="list-style-type: none"> • Fluid input/output chart • Stool chart • Serial measurement of weight • Nutrition (NBM, enteric feeding on TPN)
7	Abdominal	<ul style="list-style-type: none"> • Ascites • Stoma • Consideration of abdominal drains
8	Biochemical results	<ul style="list-style-type: none"> • U&Es (Na, Ur, Crn, GFR)
9	Thirst	<ul style="list-style-type: none"> • Subjective assessment on patient questioning
10	Drug chart	<ul style="list-style-type: none"> • Review of medications • Intravenous fluids
11	Observations	<ul style="list-style-type: none"> • Heart rate • Blood pressure (including lying and standing) • Respiratory rate
12	Temperature	
13	Other	<ul style="list-style-type: none"> • Bulging fontanelles • Assessment of CXR for signs of pulmonary oedema

and medical as well as surgical wards [2, 5, 7, 8]. Lack of knowledge around the fluid and electrolyte requirement of individual patients as well as the composition of different IV fluids have been thought to be 2 of the main issues underlying errors in prescribing. Moreover, this task is often left to very junior members of the team with the least amount of clinical experience and training, with Lobo et al. highlighting the fact that FY1s were not equipped with the experience or knowledge to safely prescribe IV fluid therapy in 2001 [3]. They

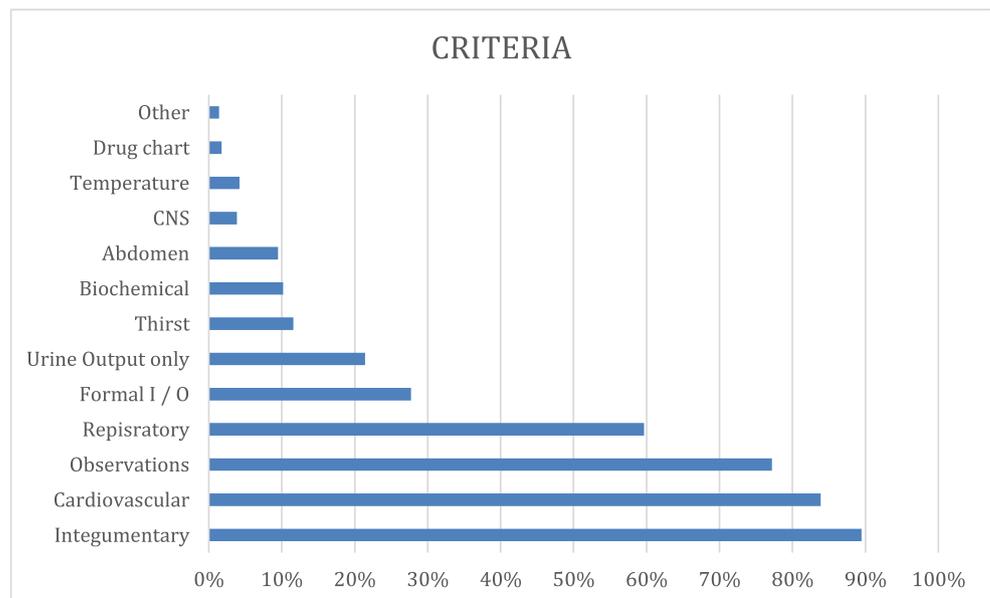
Fig. 1 Number of respondents and criteria they met



interestingly found that although most FY1s felt confident in their ability to carry out the task, their level of knowledge did not justify their confidence. This was mirrored in our study, with 69.23% of candidates reporting to be reasonably confident with fluid and electrolyte prescribing, despite the fact that only 32.87% of FY1s knew the recommended daily maintenance water requirement of a healthy adult, 31.12% the concentration of sodium in 1 L on N. saline and 41.26 and 33.57% the concentration of potassium and sodium, respectively, in 1 L of Hartmann’s solution. FY1s were more familiar with daily potassium requirements than those of sodium (58.3 vs 20.28%, respectively), and this was also noted by Lobo et al. [3], who commented on the fact that this may be partly due to

the tendency of tailoring prescriptions with sodium rich crystalloids in order to achieve a good urine output irrespective of what the cause for the reduced urine output may be. This is in conjunction with the fact that as seen in their study, as well as ours, less than 50% of respondents knew the sodium content of 1 L of 0.9% saline and 1 L of Hartmann’s solution. This pattern of overprescribing of sodium rich fluids has been noted in numerous studies and is a well-documented issue, which has still not been dealt with in clinical practice [7, 8]. More worryingly so, FY1s also seemed to lack the knowledge around how to clinically assess patient’s fluid balance, with only 16.43% knowing the minimal urine volume needed to excrete solute load and 45.10% knowing how to calculate the

Fig. 2 Fluid balance criteria assessment



desired urine output of a healthy 70-kg man. The data also suggests that FY1s are carrying out limited fluid status examinations, which could account for suboptimal fluid and electrolyte management. This could be improved by targeted teaching in the latter years of medical school, inclusion of fluid status assessment in induction procedures and in early FY1 teaching. The development of a systematic and standardised approach, much like the widely used ABCDE method of assessing a sick patient, could also be useful in improving assessment of fluid status amongst new junior doctors.

It is therefore apparent that FY1 doctors in 2018 are still lacking knowledge and understanding around key principles of fluid and electrolyte prescribing. Our study highlights knowledge gaps that impair these doctors from fully understanding one's electrolyte requirement, the electrolyte composition of IV fluids and how to replace deficits appropriately, as well as daily fluid requirements and how to assess one's fluid balance.

Poor education of the topic at undergraduate and postgraduate level has been identified as being a major cause for this gap in essential medical knowledge. Lobo et al. [4] further carried out a survey in which 60% of FY1s denied receiving any instruction on the topic, only 16% of consultants felt FY1s were adequately trained in the subject, and 15% of consultants admitted to not giving much training on the topic. Unfortunately, it appears that the situation has not changed much since the early 2000s, with only 23.43% of FY1s receiving any formal teaching on the topic at a post-graduate level and 30.77% receiving guidelines and informal teaching on the ward. This is despite the fact that, since the 2000s, a whole range of audits [8–13] and national guidelines [5] have been published in order to raise awareness and improve practice. Interestingly, these studies have shown that the introduction of guidelines [13], interactive workshops [21], and prompts in the shape of stickers [11] or lanyards [12] is effective in improving fluid prescribing by FY1 doctors. Nevertheless, it appears that FY1s are still relatively unfamiliar with the guidelines available to them and are not adequately sign posted to the correct resources or trained by more senior members of staff or the foundation programme. It is also important to note that the questionnaire was circulated around 1 month after FY1s had taken up their posts, so the post-graduate teaching programmes may have not yet reached the point of delivering teaching on fluids and electrolytes by the time the survey was circulated. Though this begs the question of whether or not FY1s should be made to do these tasks from day one, if they have not yet received appropriate training. It may also add further value to survey FY1s after towards the end of their first and last rotations.

Despite this, fluid and electrolyte teaching is a key component of the undergraduate curriculum, but at undergraduate level, 47.55 and 22.72% of FY1 rated the quality of teaching on the topic as good/very good and poor/very poor,

respectively. Those who rated it as good emphasised the importance of having numerous teaching sessions, which focused on different aspects of fluid and electrolyte management, in particular the practical aspect. Those who reported it as poor generally commented on being taught too much theory and not enough on the practical considerations behind assessing and treating a patient's fluid and electrolyte deficits—this is also reflected by the poor performance of FY1s on the question regarding examining a patient's fluid status. Many also commented on the fact that the information they were given was often confusing and at times conflicting. Another contributing factor may be the actual content of undergraduate textbooks, as suggested by a study, which concluded that the topic of IV therapy is badly covered in textbooks available to medical students and needs to be revised in order to try and improve knowledge and practice by junior doctors [22].

Another issue that needs to be taken into consideration is whether or not FY1s are in fact practicing medicine in an environment, which allows them to make accurate decisions on patient fluid and electrolyte management. NCEPOD [1] reported 20% of their patients sampled as having poor documentation on fluid balance; moreover, in Lobo et al.'s survey, only 65% of consultants felt that fluid balance charts were being accurately maintained at their trusts, with nursing shortages being the commonest reason for inaccuracies [4]. In our study, it was evident that FY1s were often left in charge of fluid prescribing, with registrars and consultants being actively involved in only 20.98 and 5.59% of circumstances, respectively. Moreover, 45.8% of FY1s reported fluid balance charts not being regularly checked, with just over 50% reporting regular chart checks at the morning ward round.

Conclusion

Our study shows us that FY1 doctors still lack knowledge and understanding around key principles of fluid and electrolyte management. This appears to be at least partly due to poor teaching of the subject at medical school and inconsistent training during the foundation years. Compared to the early 2000s, there are now comprehensive NICE guidelines [5], which can be used as a reference when managing patient IV fluid therapy and should be distributed to FY1s early in their training. With that said, major improvements in the quality of medical undergraduate and postgraduate education need to take place. How this is to take place is the main issue; perhaps, a national centralised education programme, which teaches and tests HO knowledge at least once per rotation, ideally at the start of their rotations, would be prudent. So, too, might be incorporating some element of this teaching of into specialty grand rounds, as this can be a good time to focus on important issues, which may be poorly taught and trained. The

introduction of compulsory prescribing e-learning modules has been a start but is not currently addressing the issue properly.

In addition to this, FY1s need to generally be better supported by senior members of staff when making decisions about fluid and electrolyte management, especially in the current climate of poor nursing staffing levels, where accurate fluid balance information may not always be available. As a matter of fact, the NCEPOD report [1] argued for fluid prescription to be accorded the same status as drug prescription, which generally has more senior support in clinical practice. After all, fluid and electrolyte management is a complex task, which carries serious implications for patient morbidity and mortality; it is frankly both unfair and unrealistic to expect the most junior and inexperienced members of the team to be the main decision-makers with such an important aspect of patient care.

Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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