Education

Improving intravenous fluid prescribing

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Abstract

Intravenous (IV) fluid therapy is integral to the care of patients in hospitals but involves complex decisions. Errors in fluid prescribing are common, leading to significant harm due to inappropriate fluid type, rate or volume. British national guidelines have been developed to improve prescribing, but adherence has been generally poor. The Scottish Government has set up a National IV Fluid Improvement Programme to implement national guidelines throughout Scotland. This article reviews the need for such guidance and discusses how the Scottish National IV Fluid Improvement Programme hopes to achieve its aims across Scotland. This may provide an improvement framework for fluid prescribing in other regions.

Keywords: intravenous fluids, patient safety, quality improvement, #ivfluidscot, prescribing

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Introduction

Intravenous (IV) fluid therapy is a key area of managing acutely unwell hospitalised patients. However, errors in fluid prescribing are common and contribute to patient morbidity and mortality through inappropriate prescribing.[1] Prescribing IV fluids involves complex decision-making on the indication, optimal fluid type, volume and rate. Studies have shown that junior prescribers consistently demonstrate poor knowledge associated with a large variation in their practice.[2,3] In recognition of these issues, the National Institute for Health and Care Excellence (NICE) in the United Kingdom (UK) developed guidelines for IV fluids.[1] These guidelines are used as a standard internationally as, to our best knowledge, there are no other national guidelines. However, awareness of and adherence to NICE guidelines is generally poor.[2,4,5] Following the successful introduction of NICE-based IV fluid local guidance in NHS Fife, the Scottish Government has set up a National IV Fluid Improvement Programme to implement throughout Scotland.

In this article, we briefly review basic fluid physiology as well as the history and evidence behind relevant fluid prescribing in NICE guidelines and the Scottish National IV Fluid Improvement Programme. We then review the need for such national guidance and describe how the Scottish programme aims to improve fluid prescribing across Scotland. Readers may consider using some of the tools from this programme as a framework for improving fluid prescribing in their practice.

Search Strategy

We based our review on British national guidelines on intravenous fluid prescribing in adults, in addition to searching PubMed using the key terms: intravenous fluids, fluid resuscitation, maintenance fluids, and quality improvement. We also synthesised information from specialist reports for a generalist audience.

Fluid physiology

Junior prescribers often have poor knowledge about the daily requirements of water and electrolytes in health.[2] Optimum fluid prescribing requires not only a good understanding of basic physiological principles in health, but also pathophysiology of disease processes requiring IV fluids. For example, in the postoperative period when the body has undergone stress, it retains sodium and water more avidly because of many processes.

Water, which accounts for around 60% of body mass, is found in two main body compartments: intracellular (two-thirds) and extracellular (one-third). These compartments are divided by semi-permeable membranes and movement across these membranes is governed by factors such as endothelial permeability, and oncotic and osmotic pressures. Homoeostatic mechanisms adjust renal sodium and water excretion to maintain euvolaemia, despite large variations in intake and loss. Disturbed fluid distribution between these compartments can occur in a variety of states such as physiological ageing, acute illness, co-morbidities and

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polypharmacy. This can significantly alter the assessment of fluid status and make fluid prescribing challenging.

A brief history of IV fluids

A brief historical review of fluid prescribing is informative in the current context of fluid therapy and where the current fluids we prescribe originated.

IV technology stems from studies on cholera treatment in 1831 by the pioneering Scottish physician, Dr Thomas Latta, who chose the IV route because oral hydration with drinking water and rectal saline delivery had proven ineffective.[6] Latta noted that cholera patients lost a significant amount of water from their plasma and that the key to improvement was restoring water in combination with 'oxygenating salts'.[7] Latta's insight lay in experimenting with the type of fluid as he appropriately reasoned that a salt solution could be a substitute for blood. Early solutions were unsuccessful, but his fourth attempt was associated with several successful treatments and bore a remarkable resemblance to modern IV fluids.[7] Latta's solution was revolutionary at the time, but its use waned after the cholera outbreak subsided. In his honour, a new street on the site of the Eastern General Hospital in Edinburgh, UK was named Latta Place in 2014.

During the 1880s, Sydney Ringer introduced Ringer's Lactate, the first so-called 'physiological' fluid which was later modified by Alexis Hartmann in 1932.[8] It is notable that the composition of these fluids bears little resemblance to 0.9% saline, one of the most commonly used IV fluids today. In fact, there is very little scientific basis for the use of 0.9% saline, which originates from the in vitro studies by Hartog Jakob Hamburger on human erythrocytes. In 1896 Hamburger noted that erythrocytes were least likely to undergo lysis in this solution and thus named it 'indifferent saline' to indicate that it had no effect on erythrocytes.[9] Further experimentation on freezing points led Hamburger to conclude that 'the blood of the majority of warm-blooded animals, including man, was isotonic with a sodium chloride NaCl solution of 0.9 per cent, and not of 0.6 per cent'.[9] Over time, 'indifferent saline' was corrupted to the commonly used term 'normal saline', despite there being nothing normal about 'normal saline'. Notably, clinicians have warned about the 'reckless' use of 0.9% saline since as early as 1911: 'one cannot fail to be impressed with the danger…(of) the utter recklessness with which salt solution is frequently prescribed, particularly in the postoperative period…the disastrous role played by the salt solution is often lost in light of the serious conditions that call forth its use'.[10]

The need for guidance on IV fluid prescribing

The extent of harm from inappropriate fluid prescribing is difficult to quantify because it is under-reported. A 1999 National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report highlighted that a fifth of perioperative patients receiving IV fluids suffered complications due to inappropriate fluid prescribing by inexperienced staff.[11] The 2011 NCEPOD report extended the findings of increased risk with excessive IV fluid prescribing in the pre-operative period.[12]

Errors in fluid prescribing are undoubtedly multifactorial. Studies persistently report poor knowledge of the IV fluid content among prescribers. One 2001 questionnaire study of British junior doctors in 25 hospitals found that fewer than 50% were aware of the sodium content of 0.9% NaCl or the daily adult maintenance requirements of sodium, and around 25% would prescribe significantly more than the daily sodium requirements.[3] A more recent questionnaire study reported similar findings with most of the doctors in the study unable to recall the contents of commonly used fluids and the daily adult requirements for water and electrolytes.[2]

It appears most fluid prescribing is done by recent graduates with limited experience.[13] One questionnaire study of Foundation Year 1 doctors at four different British centres found that recently graduated doctors lack confidence and the knowledge to adequately prescribe IV fluids across a variety of clinical contexts.[14] There were similar findings in a self-reported survey of Australian interns who felt less prepared for reviewing and managing fluid status.[15] Improving undergraduate and postgraduate teaching on IV fluids can help address some of these shortcomings. Structured postgraduate workshops involving teaching on fluid and electrolyte physiology improved trainee-reported confidence and mean test scores.[16]

Accurate assessment of fluid status and documentation of fluid balance are necessary for appropriate fluid prescribing. The 2014 Older People in Acute Hospitals Inspection Programme reported highly variable and inaccurate charting of fluid balance in Scottish hospitals.[17] Inadequate documentation restricts the data available to clinicians when they are asked to review such fluid prescriptions subsequently and make complex decisions. Even if the initial prescription is appropriate, subsequent prescribers may overprescribe or prescribe inadequately. This highlights the importance of a clearly documented daily fluid management and review plan.

In recognition of the issues surrounding IV fluid prescribing and the lack of standardised guidance, NICE published guidelines for the intravenous fluid therapy in adults in hospital in 2013 and updated them in 2017.[1]

Evidence behind prescribing IV fluids

There is limited high-quality randomised trial evidence for IV fluid management.[18,19] Below, we review the evidence behind the use of IV fluids in resuscitation and maintenance settings.

Resuscitation fluids

The use of IV fluids in certain scenarios, such as traumatic blood loss, is supported with good evidence,[20] unlike in sepsis and acute kidney injury where there is limited evidence to guide aspects such as the volume and rate of fluid prescribing.[21] Most guidelines for these latter

Box 1 NICE recommendation on IV fluids for resuscitation[1]

- If patients need IV fluid resuscitation, use crystalloids that contain sodium in the range 130–154 mmol/l, with a bolus of 500 ml over less than 15 minutes.
- Do not use tetrastarch for fluid resuscitation.
- Consider human albumin solution 4–5% for fluid resuscitation only in patients with severe sepsis.

scenarios advise clinicians to use their acumen to assess for hypovolaemia to guide fluid therapy. However, there is significant variability in assessing for signs of hypovolaemia. Indeed, features such as hypotension and tachycardia were found to be unreliable indicators of hypovolaemia in one systematic review assessing 30 studies.[22] There is very limited evidence to support using these variables in populations where fluid assessment is made further challenging by acute illness in patients who are already old, multi-comorbid and polymedicated. Assessing and treating patients based on these variables of hypovolaemia can lead to excessive administration of fluids and harm from hypervolaemia, including in patients with sepsis and hypotension.[23]

NICE guidelines make specific recommendations for the type of fluid to use in resuscitation (Box 1). Emerging research suggests that the type of fluid used can cause harm in specific contexts. For example, in critically-ill patients with traumatic brain injury using albumin as a resuscitation fluid rather than 0.9% saline is associated with higher mortality rates.[24] Conversely, albumin improves outcomes in a certain subset of adults with severe sepsis.[25,26] However, replacing albumin in addition to crystalloids does not improve survival rates compared with crystalloids alone.[27] Semisynthetic colloids such as hydroxyethyl starches have been compared to crystalloids in several clinical trials and have been associated with an increased risk of death and kidney injury requiring renal replacement therapy.[28] A major Cochrane review found no evidence of difference in mortality between the crystalloids and colloids in fluid resuscitation.[29]

Considering the above results and cost-effectiveness, crystalloids like 0.9% saline became the choice for IV fluid resuscitation. The debate has now shifted to the type of crystalloid. Observational studies have reported that large volumes of 0.9% saline are associated with a hyperchloraemic metabolic acidosis.[18,19] Hyperchloraemia has many biochemical consequences for the kidney including afferent arteriolar vasoconstriction leading to a fall in glomerular filtration rate and acute kidney injury.[30] These data have led to trials comparing 0.9% saline with more balanced 'physiological' solutions (such as Hartmann's or PlasmaLyte). Two recent studies have reported improved outcomes with balanced crystalloids over 0.9% saline.[31,32] However, concerns have been raised over the use of composite primary endpoints (death, renal replacement therapy and persistently raised creatinine) and over the study design of these trials,[33] but it may be some time before we get any better data.[34] In the absence of evidence suggesting inferiority compared to 0.9% saline, the theoretical benefits offered by balanced solutions give strong support for their use.

Maintenance fluids

The goal of maintenance IV fluid therapy should be to preserve the extracellular volume and to maintain normal electrolyte balance if the patient is unable to meet their maintenance requirements. Evidence suggests that maintenance fluids may be a greater source of iatrogenic harm than resuscitation fluids, through inadvertent sodium, chloride and fluid loading.[35] For several years, guidelines on maintenance IV fluids recommended the use of hypotonic solutions[35] which led to the development of iatrogenic hyponatraemia as a consequence of excess arginine vasopressin levels in acute illness.[36] The most concerning complication of this hyponatraemia is a potentially irreversible encephalopathy. Large-scale paediatric trials challenged the dogma of hypotonic maintenance solutions demonstrating the increased risk of hyponatraemia and harm.[37] This has led to changes in paediatric maintenance fluid prescribing and posed questions for adult patients.

The concern regarding hyponatraemia in children may detract from other potential harms such as fluid retention in adults. In one study, healthy adults who had fasted were given either isotonic fluid (0.9% NaCl/5% glucose and 40mM KCl) or a hypotonic fluid (0.32% NaCl/ 5% glucose and 26mM KCl) at maintenance rate.[38] The isotonic solution caused lower urine output, hyperchloraemia and volume expansion. A recent trial compared sodium-rich (154mmol/l) isotonic fluid with sodium-low hypotonic fluid (54mmol/l) in unwell adults undergoing major thoracic surgery. The study reported that sodium-rich fluids were associated with significantly greater risk of a positive fluid balance and hyperchloraemia while the hypotonic fluids

Box 2 NICE recommendation on routine maintenance IV fluids[1]

If patients need IV fluids for routine maintenance alone, restrict the initial prescription to:

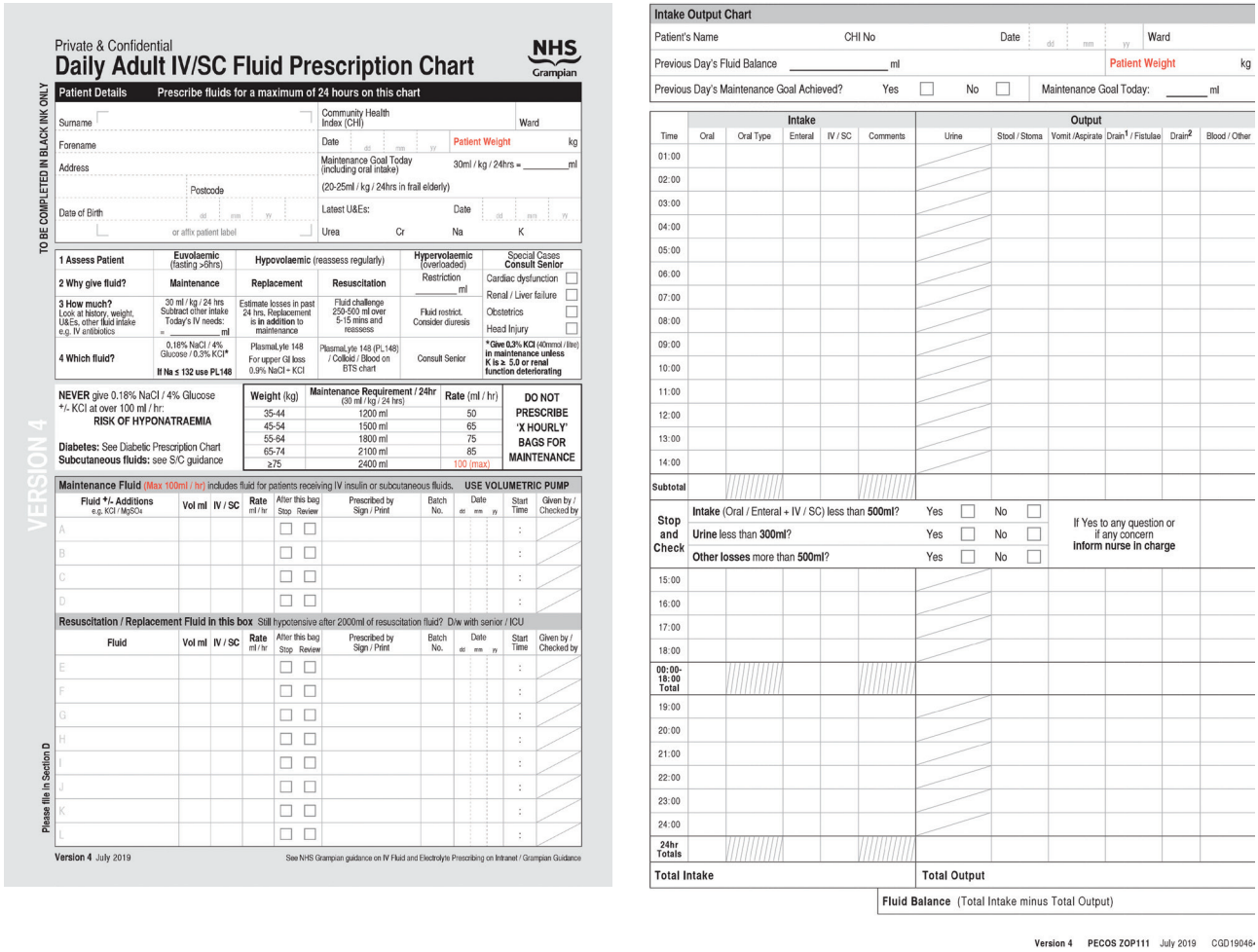
- 25–30 ml/kg/day of water and
- approximately 1 mmol/kg/day of potassium, sodium and chloride and
- approximately 50–100 g/day of glucose to limit starvation ketosis.

Consider prescribing less fluid (e.g. 20–25 ml/kg/day fluid) for patients who:

- are older or frail
- have renal impairment or cardiac failure
- are malnourished and at risk of refeeding syndrome

When prescribing for routine maintenance alone, consider using 25–30 ml/kg/day sodium chloride 0.18% in 4% glucose with 40mmol/l potassium. Routine maintenance: fluids should be weight-based prescriptions, up to a maximum of 2.5 litres per day for those weighing more than 75kg. Prescribing more increases the risk of hyponatraemia. These are initial prescriptions and further prescriptions should be guided by monitoring.

Figure 1 NHS Scotland Fluid Prescription and Fluid Balance Sheet. This is an example of a standardised prescription and fluid balance sheet used in NHS Grampian which has been modelled on the original prescription chart from NHS Fife.



Private & Confidential

Daily Adult IV/SC Fluid Prescription Chart

NHS Grampian

TO BE COMPLETED IN BLACK INK ONLY

Patient Details — Prescribe fluids for a maximum of 24 hours on this chart

Surname | Forename | Address | Postcode | Date of Birth | or affix patient label

Community Health Index (CHI) | Ward | Date | Patient Weight kg | Maintenance Goal Today (including oral intake) 30ml / kg / 24hrs = _____ml (20-25ml / kg / 24hrs in frail elderly) | Latest U&Es: Date | Urea Cr Na K

	Euvolaemic (fasting >8hrs)	Hypovolaemic (reassess regularly)		Hypervolaemic (overloaded)	Special Cases Consult Senior
1 Assess Patient					Cardiac dysfunction ☐
2 Why give fluid?	Maintenance	Replacement	Resuscitation	Restriction _____ml	Renal / Liver failure ☐
3 How much? Look at history, weight, U&Es, other fluid intake e.g. IV antibiotics	30 ml / kg / 24 hrs Subtract other intake Today's IV needs: = ml	Estimate losses in past 24 hrs. Replacement is in addition to maintenance	Fluid challenge 250-500 ml over 5-15 mins and reassess	Fluid restrict. Consider diuresis	Obstetrics ☐ Head Injury ☐
4 Which fluid?	0.18% NaCl / 4% Glucose / 0.3% KCl* If Na ≤ 132 use PL148	PlasmaLyte 148 For upper GI loss 0.9% NaCl + KCl	PlasmaLyte 148 (PL148) / Colloid / Blood on BTS chart	Consult Senior	*Give 0.3% KCl (40mmol / litre) in maintenance unless K is ≥ 5.0 or renal function deteriorating

NEVER give 0.18% NaCl / 4% Glucose +/- KCl at over 100 ml / hr: RISK OF HYPONATRAEMIA

Diabetes: See Diabetic Prescription Chart
Subcutaneous fluids: see S/C guidance

Weight (kg)	Maintenance Requirement / 24hr (30 ml / kg / 24 hrs)	Rate (ml / hr)
35-44	1200 ml	50
45-54	1500 ml	65
55-64	1800 ml	75
65-74	2100 ml	85
≥75	2400 ml	100 (max)

DO NOT PRESCRIBE 'X HOURLY' BAGS FOR MAINTENANCE

Maintenance Fluid (Max 100ml / hr) includes fluid for patients receiving IV insulin or subcutaneous fluids. USE VOLUMETRIC PUMP

Fluid +/- Additions e.g. KCl / MgSO4	Vol ml	IV / SC	Rate ml / hr	After this bag Stop	Review	Prescribed by Sign / Print	Batch No.	Date dd mm yy	Start Time	Given by / Checked by
A				☐	☐				:	
B				☐	☐				:	
C				☐	☐				:	
D				☐	☐				:	

Resuscitation / Replacement Fluid in this box Still hypotensive after 2000ml of resuscitation fluid? D/w with senior / ICU

Fluid	Vol ml	IV / SC	Rate ml / hr	After this bag Stop	Review	Prescribed by Sign / Print	Batch No.	Date dd mm yy	Start Time	Given by / Checked by
E				☐	☐				:	
F				☐	☐				:	
G				☐	☐				:	
H				☐	☐				:	
I				☐	☐				:	
J				☐	☐				:	
K				☐	☐				:	
L				☐	☐				:	

VERSION 4

Please file in Section D

Version 4 July 2019

See NHS Grampian guidance on IV Fluid and Electrolyte Prescribing on Intranet / Grampian Guidance

Intake Output Chart

Patient's Name | CHI No | Date dd mm yy | Ward

Previous Day's Fluid Balance _____ml | Patient Weight kg

Previous Day's Maintenance Goal Achieved? Yes ☐ No ☐ | Maintenance Goal Today: _____ml

	Intake					Output					
Time	Oral	Oral Type	Enteral	IV / SC	Comments	Urine	Stool / Stoma	Vomit / Aspirate	Drain[1] / Fistulae	Drain[2]	Blood / Other
01:00											
02:00											
03:00											
04:00											
05:00											
06:00											
07:00											
08:00											
09:00											
10:00											
11:00											
12:00											
13:00											
14:00											
Subtotal											

Stop and Check

Intake (Oral / Enteral + IV / SC) less than 500ml? Yes ☐ No ☐

Urine less than 300ml? Yes ☐ No ☐

Other losses more than 500ml? Yes ☐ No ☐

If Yes to any question or if any concern inform nurse in charge

15:00											
16:00											
17:00											
18:00											
00:00-18:00 Total											
19:00											
20:00											
21:00											
22:00											
23:00											
24:00											
24hr Totals											

Total Intake | Total Output

Fluid Balance (Total Intake minus Total Output)

Version 4 PECOS ZOP111 July 2019 CGD19046

were associated with a mild asymptomatic hyponatraemia.[39] These data suggest that inappropriate maintenance fluid therapy can cause significant harm. NICE guidelines make specific recommendations for maintenance fluid therapy (Box 2) and distinguishes this from replacement fluids. Lower fluid volumes are recommended in certain patients.

Scottish National Intravenous Fluid Improvement Programme

The NICE guidelines were published in 2013, but awareness and adherence to these guidelines are generally poor.[5] In 2018, a Scottish IV Fluid Improvement Programme was set up following work led by Dr Marcia McDougall, Consultant Anaesthetist in NHS Fife. This is a government-funded initiative, with the following aims:

- To standardise IV fluid guidelines across NHS Scotland
- To standardise fluid prescription and balance charts across NHS Scotland
- Ensure that all patients who require additional IV fluids have a documented weight such that weight-driven fluid volumes can be given appropriately
- Ensure patients are routinely assessed appropriately for hydration and a plan is documented for the following 24 hours

The rationale for the programme was the considerable variation in practice both within and across hospitals in Scotland leading to poor adherence to the NICE guidelines. A variety of steps have been taken to ensure that these aims are being met and we discuss these measures below. Evidence to support these measures is emerging and readers may consider some of these to improve IV fluid prescribing in their regions.

Standardised prescription and fluid balance sheet

A standardised prescription and fluid balance chart, piloted in NHS Fife, now come as one chart for a 24-hour period. The chart has been designed to provide a structured framework to support prescribers in line with NICE guidelines and to allow documentation of weight and a plan for maintenance goal over a 24-hour period. There is a prompt to remind prescribers to review the latest laboratory results. This is followed by four structured questions:

1. Is the patient hypovolaemic, euvolaemic or hypervolaemic? This involves an assessment of the fluid status of the patient. Hypervolaemic patients may need their fluid restricted. Certain special cases involving patients with cardiac, renal or liver dysfunction or patients with head injury need early senior input.

2. Why give IV fluid? Fluid prescribing should be done for three main reasons: maintenance, replacement or resuscitation. A patient may not need IV fluids.
3. How much IV fluid? The amount of fluid will be directed by the reason for giving IV fluids e.g. adults need 25–30ml/kg of fluid over a 24-hour period either through the oral or IV route. The charts remind prescribers to consider other sources of intake such as IV antibiotics.
4. Which fluid? The choice of IV fluid will also be guided by the reason for giving IV fluids e.g. for maintenance, IV fluids 0.18% NaCl/4% glucose with or without added potassium, is recommended in line with NICE guidelines.

The fluid prescription charts also have NICE guideline recommended weight-based rates in ml/hr for maintenance fluids with a prompt reminding the prescriber not to prescribe using "x hourly". The prescription area has maintenance fluid prescribing separated from resuscitation and replacement prescribing. Limited spaces are incorporated into the design of the prescription. For example, there are only eight lines for prescribing in resuscitation/replacement fluids – this is enough for 2000ml in 250ml boluses at which point senior help or higher levels of care would be appropriate. Each prescription is associated with a subsequent fluid plan: need for further review or stopping intravenous fluids.

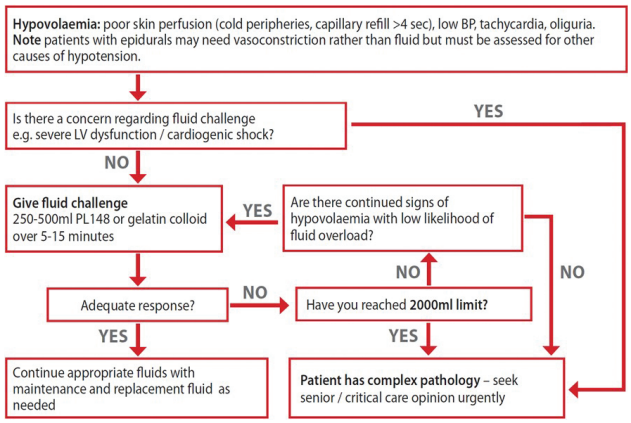
The fluid balance section has space to document hourly intake and output. This section is subdivided into sources such as oral, drains or intravenous. There are prompts to calculate subtotals at 2pm and 6pm to allow earlier detection and recognition of the deteriorating patient. There is a 'Stop and Check' prompt at the 2pm subtotal to respond to those patients with limited total oral intake, increased losses or low urine outputs. There is space to document the total intake and total output over 24 hours and subsequently document the fluid balance.

Health Boards across NHS Scotland were encouraged to use the NHS Fife example and adapt charts as required for local implementation. Some boards decided to maintain their own fluid balance charts, but aimed to incorporate the changes outlined above to improve IV fluid management. Figure 1 shows such an example from NHS Grampian.

Education, awareness and regular audits

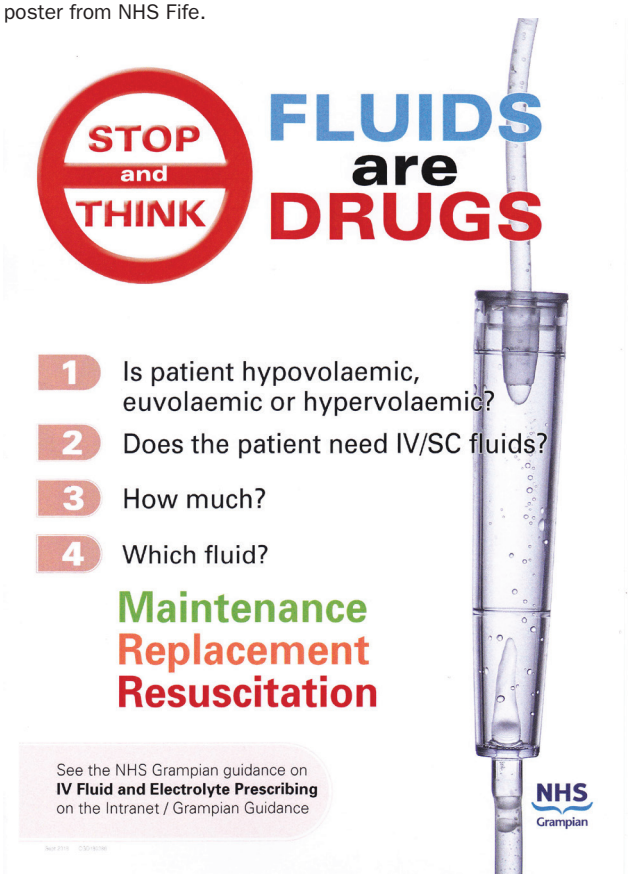
Educational approaches and audits have been shown to improve prescribing practices and documentation in line with the NICE guidelines in other UK centres.[5,40] In Scotland, the National IV Fluid Programme is working with all NHS Boards to address the educational needs of both undergraduates and postgraduates in the medical and nursing profession. Electronic learning resources through various platforms including TURAS and LearnPro, developed with NHS Fife, will be available for all clinical staff in Scotland. A variety of pocket guidelines, incorporating fluid resuscitation algorithms (Figure 2) have also been developed to summarise the NICE guidelines. These algorithms were developed from local guidelines and fluid information leaflets: 2009 Southampton Fluid Guidelines. Furthermore, posters highlighting the importance of giving

Figure 2 Fluid Challenge Algorithm. This is the fluid challenge algorithm included in pocket guidelines in NHS Grampian. These pocket guidelines were modelled from NHS Fife guidelines which in turn were modelled on the 2009 Southampton Fluid Guidance and the work of Dr Aminda de Silva. Abbreviations: *PL148* – PlasmaLyte 148; *BP* – blood pressure; LV – *left ventricular.*



fluid prescribing the same importance as drug prescriptions have been placed around Scottish hospitals (Figure 3). In NHS Grampian and the University of Aberdeen, medical curricula provide dedicated time to deliver teaching on IV fluid prescribing and have incorporated new guidelines. In addition, postgraduate doctors get IV fluid teaching during their first year.

Figure 3 Fluids are Drugs Poster. This poster was displayed across hospitals in NHS Grampian; it highlights the importance of giving fluid prescribing the same importance as drug prescriptions. It also has the four key questions that prescribers should consider before prescribing fluids. This has been modelled on the original poster from NHS Fife.



Regular audits are being used to incrementally improve fluid prescribing. Data from audits is fed back to clinical staff to foster an environment of continuous learning and improvement. In 2014, NHS Fife was the first Scottish board to appoint a Quality Improvement Nurse for Fluid Management, and this post has been a model for the appointment of other fluid nurses and QI Fluid personnel across Scotland. This role has been instrumental in the early successes of the programme.

Summary

- Errors in fluid prescribing are common and can lead to harm.
- Guidelines from NICE are available to improve the quality of fluid prescribing but are poorly adhered to.
- The Scottish National Intravenous Fluid Improvement Programme is using a variety of measures to implement national guidelines across Scotland, including a standardised prescription and fluid balance sheet, educational measures and regular audits.

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