A Consensus Recommendation for Pediatric Intravenous Maintenance Fluid in Belgium

On Behalf of the Be-PIV Group

Arne Boret[a], Milou Blits[b], Ann Raes[a], Sara Debulpaep[a], Elisabeth LIM Duval[c]

[a] Department of Pediatrics, Ghent University Hospital, Ghent, Belgium
[b] Department of Pediatrics, Antwerp University Hospital, Edegem, Belgium
[c] Department of Pediatric Critical Care Medicine, Antwerp University Hospital, Edegem , Belgium

els_duval@yahoo.com

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Abstract

Prescribing intravenous maintenance fluids is a daily practice for pediatricians worldwide. Failure to administer the correct fluid type or rate can impact morbidity and mortality. Despite this, different regimens are used based on old guidelines. This narrative review aims to formulate a guideline for the Belgian clinician. We searched databases for manuscripts on pediatric intravenous maintenance fluid therapy. Studies were evaluated on seven relevant topics, and our expert group discussed, formulated, and reviewed recommendations, resulting in a guideline for hospitalized children outside the neonatal period. We recommend the use of isotonic, preferably balanced, solutions with glucose 5 g/L and potassium 20 mEq/L with a restricted rate in most hospitalized children. Our guideline also provides recommendations for work-up and daily monitoring to avoid complications during maintenance therapy. Specific situations or comorbidities may warrant a tailored approach, as shown in the proposed algorithm.

Introduction

Intravenous (IV) fluid therapy is one of the most common interventions in hospitalized children (1). Several reasons for prescribing IV fluid therapy can be distinguished: to resuscitate (and correct a relative or true fluid deficit), to replace (and correct abnormal losses, e.g., drains, burns, diarrhea, vomiting), or to maintain. Although there is no single definition for IV fluid maintenance, it is usually described as the water and electrolyte prescription designed to replace anticipated physiologic water and electrolyte losses over the ensuing 24-hour period (2). It aims to maintain electrolyte and free water homeostasis while also providing a source of energy (2-5).

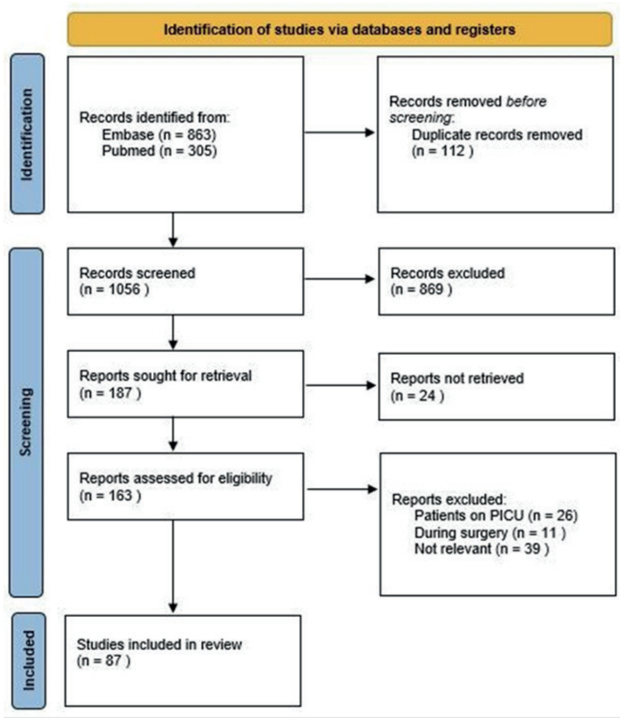
Fluids can thus be administered for different reasons, sometimes even simultaneously, and as such might have different contents and rates (2). Careful prescription, administration and monitoring of IV fluids are critical (6). Failure to administer IV fluids correctly can significantly impact morbidity and mortality (7). Prescribing them should be done with the same caution and accuracy as prescribing medications, considering the 4 D's: drug (which fluid?), dose (what rate?), duration (how long?), and de-escalation (monitoring) (8).

Our group has recently published a consensus recommendation on pediatric fluid resuscitation for the Belgian clinician (9). This narrative review will focus on IV maintenance therapy in hospitalized children. Based on this, we aim to formulate a guidance for Belgian clinicians applicable to children outside the neonatal period and under 15 years of age, in order to harmonize the quality of IV maintenance fluid administration in pediatrics according the current state of the art.

Methods

There is no MESH term for 'maintenance fluid,' so we searched the databases PubMed and Embase for English articles with the terms: 'infusions, intravenous,' or 'fluid therapy' combined with 'child' and the free text term: 'maintenance.' We identified 1056 articles (Figure 1). These articles were screened for titles and abstracts: articles on IV fluid resuscitation, replacement, or other use were excluded. Other exclusion criteria included adults or neonates. The remaining 187 articles were retrieved and assessed. Articles concerning children with specific underlying diseases (e.g., diabetic ketoacidosis) or fluids used per-operatively were excluded. In the end, 87 articles were retained. In addition, the reference lists of landmark papers were also checked. In concordance with journal guidelines, the most important ones were withheld in the reference list.

Figure 1: Prisma flowchart.



Studies were evaluated on seven relevant topics: target population, fluid tonicity, balanced or non-balanced fluid, glucose, potassium and other components, rate and monitoring. A series of recommendations were derived and voted by our expert group through two rounds of voting using a modified Delphi process to reach consensus. For each question, the consensus within the expert group is expressed as a percentage. In most cases, the consensus was strong (>90%). Based on these recommendations, an algorithm was proposed.

Results

Recommendation 1.
Our IV maintenance guideline is applicable for children < 15 years (excluding neonates) in whom enteral fluid is not allowed or possible (consensus 86 %).

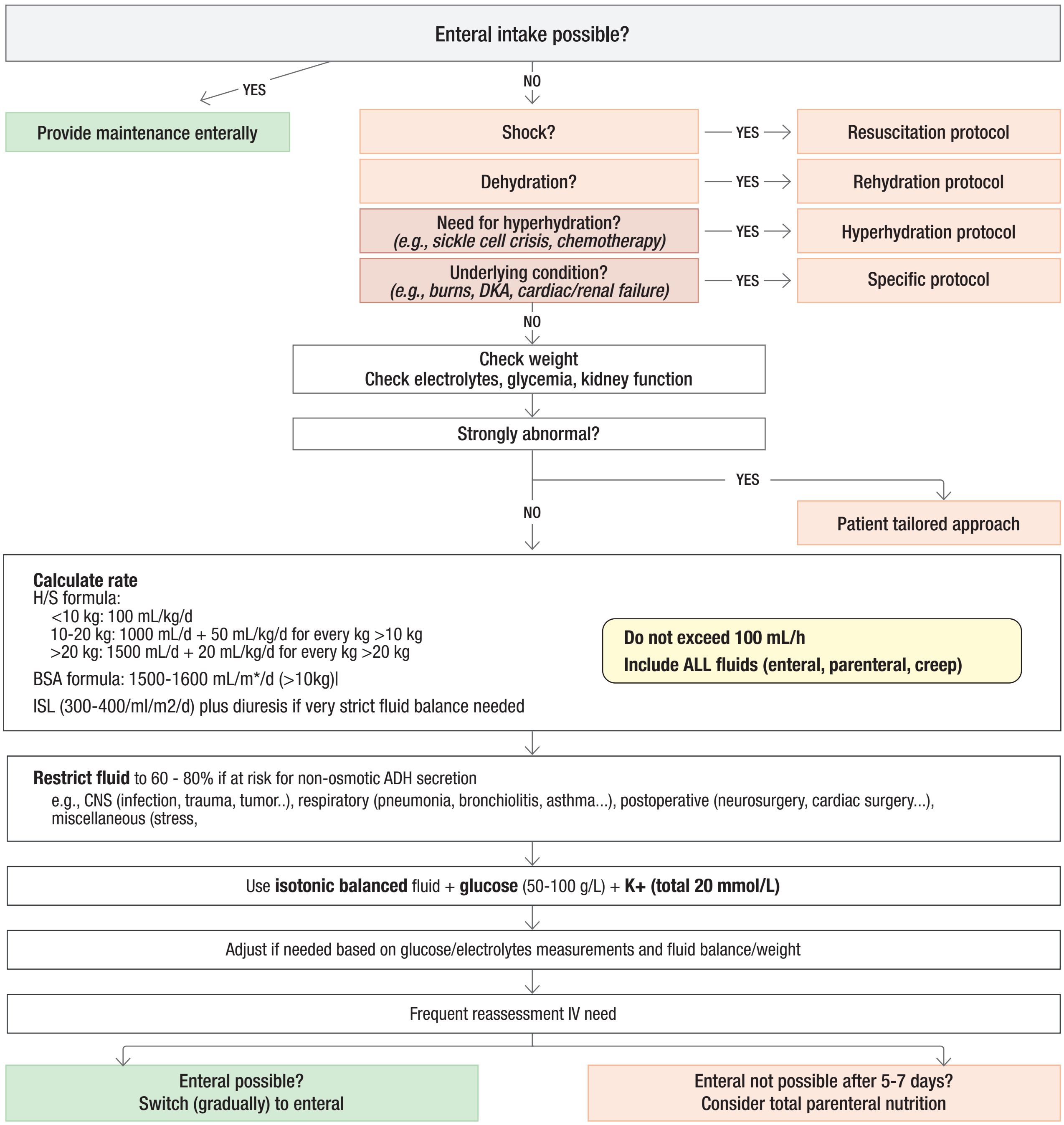
A practical approach regarding pediatric maintenance fluid is presented in Figure 2. This guideline concerns only maintenance fluid in children younger than 15 years of age, excluding neonates. It should be distinguished from fluid therapy in resuscitation, or during rehydration or replacement (e.g., burns, diabetes insipidus, diarrhea…). The expert group agreed that, where possible, maintenance fluid should always be provided orally or enterally, unless not possible or allowed. The need for (total or partial) IV maintenance fluid should be reconsidered daily.

Our proposed IV fluids cannot be given for a prolonged period of time. If the child is unable to start enteral intake within a week, parenteral nutrition should be considered (10).

In neonates, our proposed glucose content may be too low, with the risk of developing hypoglycemia, and the sodium content maybe too high (7). For the upper age limit, we base ourselves on the common definition of a child according to the pediatric care program.

This guideline is easily applicable in many patients with adequately functioning homeostatic renal, cardiocirculatory and metabolic systems. However, there is no "one size fits all" fluid. Most hospitalized children have underlying conditions or diseases, and their needs may vary accordingly (10-15). Some of the conditions that require careful consideration are added in the presented algorithm (Figure 2). The list is not exhaustive

Figure 2: Proposed algorithm for pediatric maintenance fluid in children < 15y, neonates excluded.



but provides a good overview (3, 10, 16). In these circumstances, the choice of IV fluid, its rate and its content should be tailored to the child's underlying illness and regularly reevaluated.

Recommendation 2.
Maintenance fluid should be isotonic (consensus 100 %).

Tonicity refers to the effect an IV fluid has on the osmolality of the extracellular fluid (ECF) (Table 1) (7). An isotonic solution has a concentration of dissolved particles equal to that of intracellular fluid (ICF). Osmotic pressure will be the same inside and outside the cells, so no fluid movement occurs. The tonicity of IV fluids is mainly determined by the concentration of sodium. However, different ranges of isotonicity are used throughout literature with sodium concentrations of 121 - 160 mmol/L (Cochrane), 131 - 154 mmol/L (National Institute for Health and Care Excellence or NICE) and 130 - 154 mmol/L (American Academy of Pediatrics or AAP) (1, 3, 7).

For decades, maintenance fluids in children were hypotonic, following recommendations by Holiday and Segar in 1957, who based maintenance requirements for water on caloric expenditure (5). This resulted in glucose-containing solutions with low sodium content. Because glucose is metabolized to carbon dioxide and water once it enters the cell, the net result is a hypotonic solution. Case reports and observational studies in the 1990s followed by reviews in the early 2000s, suggested a potential for hyponatremic encephalopathy and mortality with hypotonic fluids (17). Hypotonic fluids can generate dilutional hyponatremia, leading to an osmotic shift of free water from the ECF to the ICF. This is particularly worrisome in the brain, where edema could trigger hyponatremic encephalopathy, characterized by apathy, vomiting, agitation, headache, convulsions and coma. Children are at higher risk as they develop hyponatremic encephalopathy on higher plasma sodium levels than adults. Moreover, due to a higher brain/skull ratio and because children's brains contain more water, there is a higher risk of brain herniation (6, 18). Even mild hyponatremia was associated with adverse clinical outcomes in children (18).

The following years were characterized by ongoing debates between those in favor of isotonic solutions (arguing that fluids containing higher sodium reduce the risk of hyponatremia due to an inability to excrete free water) and those in favor of hypotonic solutions (who relate hyponatremia to excess volume administration and not to a dilutional effect of free water intake) (17). In the end, different randomized controlled trials (RCTs), systematic (Cochrane) reviews and meta-analyses provided increasing evidence that compared to hypotonic maintenance fluids, isotonic solutions do significantly reduce the risk of hyponatremia, particularly the first 24 hours, with some evidence that this effect persists at 48 hours (1-4, 7). Currently, supporting data are available in pediatric intensive care units (PICU) and non-intensive care settings: fluid type and not rate or volume, is the strongest significant predictor of hyponatremia (1, 3). The use of isotonic fluid could theoretically cause hypernatremia (4). However, different studies and a meta-analysis did not support this (1, 3). Inadequate fluid volume is thought to be more important to the development of hypernatremia than the actual amount of sodium (18).

Another theoretical concern with the use of isotonic fluids is the so-called sodium load (19). In adult patients, it is thought that an additional sodium burden, produced by the administration of isotonic fluids, could lead to a positive fluid balance and respiratory complications (20). The underlying mechanisms may be the inability of the kidneys to deal with a relatively high sodium load, which may promote fluid retention by inhibiting diuresis at renal collecting tubules (16). This effect is thought to be significant in cases of impaired diuresis or capillary leak (16). Reviews in pediatrics do not support this (16, 21, 22). However, a tailored approach with appropriate monitoring, bearing comorbidities in mind, should be advocated in very sick children (16).

When the risk of hypotonic fluids became apparent, new guidelines emerged with a shift from hypotonic to isotonic fluids (1, 4, 22). NICE recommends the use of isotonic crystalloids that contain sodium in the range of 131 - 154 mmol/L (7). The advice of both the AAP (promoting the use of isotonic solutions with appropriate potassium and dextrose) and the Canadian Pediatric Society (NaCl 0.9% with addition of glucose 5%) is similar (3, 23). A more recent article from the European society of Pediatric and Neonatal Intensive Care (ESPNIC) suggests that isotonic balanced solutions providing some glucose (4 - 10%) and limited amounts of potassium (+/- 4 mmol/L), would meet most children's requirements of IV maintenance fluid (2).

Despite these guidelines from highly respected institutes, a survey in 2021 still showed a wide variation in practice in prescribing IV maintenance fluids in hospitalized children, both in PICU and pediatric wards (22). Our own survey amongst Belgian pediatricians supports these findings: more than 50% of all pediatricians continue to use (different) hypotonic fluids as maintenance therapy with a wide variation (data to be published). Breaking through dogmas that have been followed for decades is always difficult. On top of that, most recommendations lack practicality and do not include all elements of IV maintenance fluids.

Recommendation 3.
Maintenance fluid should be preferably balanced (consensus 100 %).

A balanced solution has the entire content of all electrolytes equal to plasma, whilst at the same time maintaining electrical neutrality (the number of free cations equals the number of free anions). Most commercially available IV fluids add organic anions such as acetate or lactate (which are metabolized to bicarbonate) to balance the total amount of positive cations. NaCl 0.9% however, contains a supra-physiological concentration of chloride (Table 2). When using NaCl 0.9%, the rise in plasma chloride leads to increased excretion of bicarbonate and metabolic hyperchloremic acidosis ensues (16). This may be especially prominent in cases of increased bicarbonate losses (e.g., diarrhea) or when large volumes are used as in resuscitation (3, 16). Using balanced fluids lowers the risk of metabolic hyperchloremic acidosis (24). The latter showed to be related to worse outcomes in adults, including increased acute kidney injury (AKI) and mortality (25). Hyperchloremia alone was associated with morbidity and mortality in pediatric sepsis (26).

There is much data on the use of balanced fluids in resuscitation or perioperatively (9, 27). When looking at maintenance fluids, studies are scarce. In a meta-analysis of 5 studies with 283 patients, balanced solutions slightly but significantly reduced the length of stay (LOS) in critically and acute ill children (2). Another RCT also favored the use of balanced fluids postoperatively (28). In a retrospective cohort study, NaCl 0.9% as a maintenance fluid was a predictor of hyperchloremic acidosis, but this was not associated with an increased risk of AKI, feeding intolerance or PICU-acquired weakness. Of equal importance

Table 1 : Tonicity.

Type of fluid	Effect on extracellular fluid	Examples
Hypotonic	Decreases osmolality and ECF	Dextrose 5 - 10% Glucion 5 - 10% Glu 2.5% / NaCl 0.45% Glu 3.3% / NaCl 0.3%
Isotonic	No effect	NaCl 0.9% Plasmalyte Hartmann's solution
Hypertonic	Increases osmolality and ECF	NaCl 3% NaCl 5%

ECF = extracellular fluid

Table 2 : Content of different isotonic solutions (all mmol/L).

Substance	Plasma	NaCl 0.9%	Ringer's lactate	Hartmann's solution	Plasmalyte
Sodium	135 - 145	154	130	131	140
Potassium	4.0 - 5.0	0	4.5	5	5
Calcium	2.2 - 2.6	0	2.7	4	0
Magnesium	1.0 - 2.0	0	0	0	1.5
Chloride	95 - 110	154	110	111	98
Acetate	0	0	0	0	27
Lactate	0.8 - 1.8	0	28	29	0
Gluconate	0	0	0	0	23
Bicarbonate	23 - 26	0	0	0	0

was the conclusion that substantial sources of chloride load appeared to come from fluids administered with medications and IV flushes (29). Other studies could not demonstrate beneficial effects of balanced fluids as maintenance (18).

A theoretical benefit of balanced solutions is their buffering effect: lactate and acetate are metabolized into bicarbonate, which alkalinizes plasma and could be beneficial in metabolic acidosis, a hallmark of shock. NaCl 0.9% on the other hand, could be beneficial to counter alkalosis occurring in significant vomiting (e.g., pyloric stenosis).

Studies in this area are not robust enough to be conclusive at this stage. Although the occurrence of hyperchloremic acidosis when using NaCl 0.9% seems common, more trials are needed to define its clinical importance (6, 10, 29). Yet balanced fluids have many physiologic advantages. Considering the limited extra cost and potential benefits, and in accordance with NICE, AAP and ESPNIC, the expert panel unanimously recommended using preferably balanced solutions (1-3).

There is a lack of evidence to recommend one balanced fluid over another, but Plasma-Lyte 148® seems to be a suitable choice for general use and even more in critically ill children because of its low chloride content (Table 2) (7, 10). Lactate buffer solutions should not be used in case of severe liver dysfunction to avoid lactic acidosis.

Recommendation 4.
Maintenance fluid should contain an appropriate amount of glucose (50 g/L) (consensus 100 %).

Glucose alters the osmolarity of IV fluids, but because it is rapidly metabolized after entering the bloodstream it does not affect the tonicity of solutions in vivo (3, 6). Glucose in maintenance fluid is necessary to prevent starvation ketoacidosis and hypoglycemia but cannot be excessive to avoid hyperglycemia. Guidelines remain vague about its concentration: sufficient but not excessive (2).

Again, most of the available data on the use of glucose-containing solutions in children is derived from a perioperative setting: a concentration of glucose of 1 to 2.5% is recommended as a compromise between hypoglycemia (and lipolysis) and hyperglycemia (due to stress-induced insulin resistance) (30). These concentrations may however not provide enough glucose if used outside the perioperative setting (2). In one trial almost 40% of children <6 years receiving glucose 2.5% postoperatively developed hypoglycemia and/or ketosis (18). The use of glucose 5% in these circumstances might be a safer approach and it does not seem to induce hyperglycemia (11).

The expert panel recommends that glucose (50 g/L) be added to pediatric maintenance IV fluids guided by bedside glycemia monitoring. However, local compounding may pose significant risks to the patient regarding the uncertainty in physicochemical stability, microbial contamination, prescription and preparation errors in electrolyte manipulation, and alteration of the tonicity and/or the balanced nature of the original fluid (31). A commercially available balanced isotonic fluid containing 5% glucise could be PlasmalyteG5, available in Belgium. The use of higher glucose concentrations (e.g. 100 g/L) could be considered for subgroups outside our target population (e.g., neonates) or when severe fluid restriction is needed.

Recommendation 5.
Maintenance fluid should contain 20 mEq/L of potassium (consensus 83 %). There is insufficient evidence to recommend routinely adding other electrolytes, vitamins or trace elements (consensus 100 %).

Evidence is lacking on the use of potassium in IV maintenance fluid; it is probably not necessary to add potassium if only a short period must be bridged (6). However, If the period is longer, the addition of potassium is important and should be appropriate: it helps regulate fluid balance, muscle contractions and nerve signals (3, 10). Usually, a daily intake of about 2 mEq/100 mL/day is advocated, based on the same article by Holiday and Segar, after confirmation of normal serum potassium and in patients without concern for hyperkalemia (e.g., severe kidney disease, rhabdomyolysis) (5, 10, 16). Note that the recommended daily potassium intake is based on 100 mL of fluid to be infused and not on kg of body weight, which is routinely forgotten (12).

If a total of 20 mEq/L is used, potassium intake will decrease from 3 mEq/kg/day in an infant of 3 kg, to 2 mEq/kg/day in a toddler of 10 kg, 1 mEq/kg/day in a child of 30 kg and 0.6 mEq/kg/day in an adolescent of 60 kg, acceptable amounts to temporarily meet daily need. Several RCTs contained 20 mmol/L of potassium, but there were no data on serum potassium levels (10). If a balanced solution is used, it is thought that no additional potassium is needed (10). However, most balanced solutions contain only around 5 mEq/L of potassium (Table 2).

Careful attention should be paid to the child with kidney failure. Fluids containing potassium, such as balanced crystalloids, have historically been avoided in these children due to the risk of hyperkalemia. However, their potassium content is usually lower than that of a hyperkalemic patient. Moreover, potassium shifts (due to unbalanced solutions) may have a greater effect on the serum potassium than the actual concentration of potassium in the infused solution. For most patients (with or without hyperkalemia) the effect of the potassium already present in balanced solutions is minimal.

There is insufficient evidence for the routine addition of magnesium, calcium, phosphorus, vitamins or other trace elements to maintenance fluid outside the neonatal period (2). Therefore, we don't recommend it except in children with observed deficiencies. Some balanced fluids contain calcium (e.g., Ringer's lactate or Hartmann's solution), which is incompatible with blood products or ceftriaxone (6). The addition of magnesium (as in Plasma-Lyte 148® with or without glucose) is presumed to have less significant incompatibilities (6, 10).

Table 3 : Different ways to calculate rate (excluding neonates).

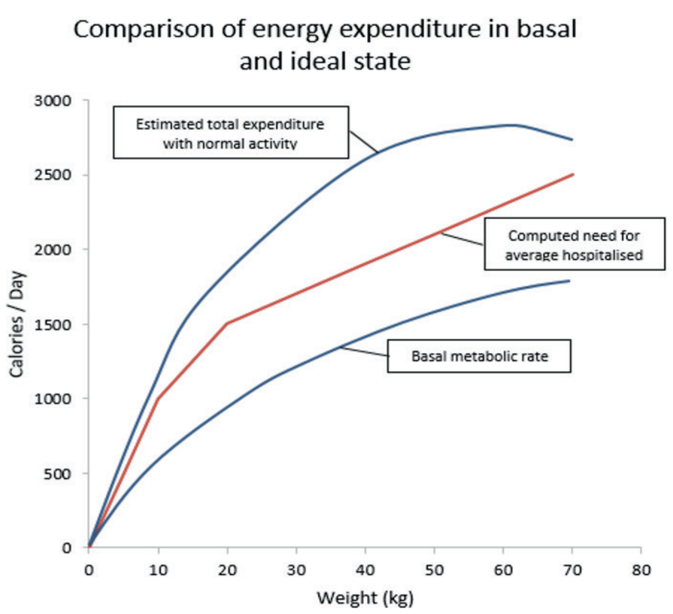
Weight (kg)	H/S	4-2-1	Oh
<10	100 mL/kg/day	4 mL/kg/h	4 mL/kg/h
10 – 20	1000 mL/d + 50 mL/kg/day for kg > 10 kg	40 mL/h + 2 mL/kg/h for kg > 10 kg	20 mL/h + weight (kg) x 2
> 20	1500 mL/day + 20 mL/kg/day for kg > 20 kg	60 mL/h + 1 mL/kg/h for kg > 20 kg	40 mL/h + weight (kg)
Alternative approach for children > 10 kg based on body surface area: 1500 - 1600 mL/m2/day			
Alternative approach if strict fluid balance is required: ISL within the range of 300-400 mL/m²/day plus urinary output.			

H/S = Holliday and Segar. ISL = insensible losses.

Recommendation 6.
Rate should be based on the Holliday/Segar or BSA (if > 10 kg) formula, provided the following restrictions are applied: do not exceed 100 mL/h, restrict in children with non-osmotic ADH release, and include all fluids given (par)enterally (consensus 89%).

Holiday and Segar (H/S) published their data on maintenance water requirements parenterally in 1957. They observed a linear relationship between water needs (urinary and insensible losses (ISL)) and energy metabolism. Since maintenance therapy replaces these losses, water requirements roughly equal caloric expenditure (1 mL of water equals 1 kcal). The relationship between weight and energy expenditure on the other hand was nonlinear. The caloric expenditure, and therefore fluid requirement, for the hospitalized child was arbitrarily estimated to be midway between the basal energy requirement and the energy requirement of normal active children (Figure 3). The nonlinearity led to the well-known formula of maintenance needs: 100 mL/kg/day for the first 10 kg, 50 mL/kg/day for the next 10 kg and 20 mL/kg/day for each kg over 20 kg (Table 3) (5). In anesthetics, the formula was simplified to an hourly requirement referred to as the "4-2-1 rule" (4 mL/kg/h for the first 10 kg, 2 mL/kg/h for the second 10 kg and 1 mL/kg/h for each subsequent kg). In 1980, Oh alternatively changed the formula into: 4 mL/kg/h for children between 3 - 10 kg, 20 mL/h + weight (kg) × 2 mL/h for children between 10 - 20 kg, 40 mL/h + weight (kg) for children over 20 kg (13). It was only later that Adelman and Solhaug calculated the rate using the body surface area (BSA), assuming that caloric expenditure is related to BSA (1500 - 1600 mL/m2/day). Their method however cannot be used for children under 10 kg.

Figure 3: Energy expenditure in children with normal activity, basal and when hospitalized. Adapted from Holliday and Segar (5)..



The H/S formula remains the most widely used formula since its original publication many decades ago. Although safe and easy to use, some remarks should be considered.

First, a maximum of 2400 mL/day should not be exceeded (7, 10). Second, there is often confusion about the difference between oral and IV fluid requirements for infants. The water requirement is identical for both routes of administration (100 mL/kg/day). However, the relatively low energy density of milk means that infants need larger volumes of milk to provide adequate nutrition, leading to volume of 150-170 mL/kg/day if all intake is enteral.

Third, all fluids administered to a child must be considered, including fluids as medication vehicles and flushes to keep lines open which often contribute to a significant volume load (29). These fluids have been termed fluid creep and should be subtracted from the total daily maintenance needed before prescribing rates (14).

Finally, the total maintenance fluid as calculated by the H/S formula was based on the usual water and electrolyte requirements of the average hospitalized child fifty years ago. Today, the average hospitalized child is different, with many having complex diseases, undergoing complex operative procedures, often with substantially shortened LOS. Often these children have increased levels of antidiuretic hormone (ADH), which reduces the ability to excrete free water (6, 10). Excess ADH secretion due to non-osmotic stimuli can result from postoperative stress, central or respiratory infection, persistent nausea, coma, head injury or positive pressure ventilation, to name but a few (6, 17, 18). These children require less fluid than prescribed by the abovementioned formula (2). If fluid is not restricted, hyponatremia will develop regardless of its tonicity (15). The safest approach is tailoring fluid need by assessing urine output and concentration, but this approach is difficult to achieve and not practical. Different restrictions of calculated fluid requirements by the H/S formula have been proposed: 50 - 66% in children with central or respiratory infections, 65 - 85% for children in PICU, and 50 - 60% in several central nervous conditions (e.g., cerebral edema, meningitis, encephalitis, or major head injury) (2, 6, 10). NICE recommends fluids restriction to 50 - 80% or fluid reduction calculated based on ISL within the range of 300-400 mL/m²/day plus urinary output (7).

Even in the absence of increased ADH secretion, other situations may warrant careful fluid prescription, such as when children are at risk for edema, as in heart, kidney or hepatic failure (2). Fluid requirements can also increase in children with high solute loads, such as glycosuria in diabetic ketoacidosis, or severe catabolism with high protein losses as in burns or crush injuries. To a lesser extent this may also be the case in children with recurrent episodes of high fever or prolonged tachypnea. In these children the BSA formula may be more appropriate, adding the increased amount of ISL (extra 100 mL/m2/day for each degree above 37.8°C).

Restricting IV maintenance fluid tends to lower the LOS in the PICU, and other studies have shown a lower occurrence of hyponatremia (2). However, robust data are difficult to obtain, when maintenance therapy has been applied erroneously (e.g., as a deficit therapy for which it was not designed) or the exact volume provided is not reported.

Taking all of this into consideration, the expert panel decided that either the H/S or BSA (if > 10 kg) can be used, but only if these restrictions are strictly followed:

- A rate of 100 mL/h should not be exceeded.
- Restrict the rate (50 - 80%) in children with conditions at risk for non-osmotic ADH release.
- All fluid, including fluid creep and enteral fluid, should be considered.

Recommendation 7.
Regular monitoring is mandatory when giving IV maintenance fluid to children to prevent fluid overload and prolonged stay (consensus 92 %).

If indicated, IV maintenance should be considered after a work-up including at least weight and an evaluation of the hydration status (both clinically and by blood tests including glycemia, electrolytes and kidney function tests) (3, 7). During IV maintenance therapy it is recommended to monitor the child (heart rate, blood pressure) and to check the fluid balance and weight regularly. Fluid balance charts are notoriously difficult to maintain accurately, clinical assessment is not always easy and objective, and even urine output can be difficult to follow, especially in a young child. Daily measurement of body weight is the most optimal fluid balance parameter but is not always feasible in a very sick child (7, 10). However, we recommend assessing body weight daily in children under two years of age and 2-3 times per week in older children. A change of 5% of body weight should alert the clinician to reconsider fluid intake (2). In acutely ill children, electrolyte concentrations should be checked at least daily (2, 7). In other children this should be done according to the risk level and proportion of IV maintenance fluid (e.g., daily if > 50% of maintenance fluid requirements are intravenous) (10). In case of electrolyte abnormalities, paired urine and plasma osmolarity and electrolyte profiles may be useful to guide fluid prescription (10). A combination of careful monitoring of clinical signs, strict recording of fluid intake and output and measurement of patient weight is likely to be more effective in estimating body fluid status than reliance on one single approach.

Conclusion

Our group attempted to provide the Belgian clinician with recommendations regarding IV maintenance therapy in hospitalized children. Outcome proved to be inconsistent between studies and the target population was often heterogeneous. Recommendations are therefore based on consensus within the expert group, and most, if not all, consistent with international guidelines.

As in other guidelines, we also recommend isotonic, balanced solutions with varying glucose concentrations (from 1 to 10%) and an appropriate amount of potassium (20 mEq/L) ensuring safe IV fluid therapy in children. These solutions should be available in a range of packaging formats to reduce their environmental footprint (31). Although isotonic balanced solutions containing 5% glucose are available in Belgium, their insufficient potassium content makes them less feasible for IV maintenance.

Obviously, this is less important if only a few of hours of IV fluid are needed. Nevertheless, when maintenance fluids are prescribed, they must be given the same consideration as other medicines regarding indications and contraindications, content, monitoring and, particularly, volume. Giving the wrong solution, the wrong volume, to the wrong patient is clearly inappropriate fluid management. The best way to avoid dangerous electrolyte imbalances, such as hyponatremia, is to monitor fluid balance (weight) and plasma sodium concentration regularly.

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A. Boret, S. Debulpaep, A. De Guchtenaere, Department of Pediatrics, Ghent University Hospital, Ghent, Belgium; V. De Smet, Department of Pharmacy, Ghent University Hospital, Ghent, Belgium; T. Detaille, Department of Anesthesiology, Cliniques Universitaires St. Luc, Catholic University of Louvain Medical School, Brussels, Belgium; E. Duval, Department of Pediatric Critical Care Medicine, Antwerp University Hospital, Antwerp, Belgium: N. Godefroid, Pediatric nephrology, Cliniques Universitaires St. Luc, Catholic University of Louvain medical School, Brussels, Belgium; A. Raes, Department of Pediatric Nephrology and Rheumatology, Ghent University Hospital, Ghent University, Ghent Belgium; K. Van Hoeck, Department of Pediatric Nephrology, Antwerp University Hospital, Antwerp, Belgium; F. Vermeulen, Department of Pulmonology, University of Leuven, Leuven, Belgium.

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