# Maintenance Intravenous Fluids in Pediatrics: Survey in Belgium about Daily Practice

Milou Blits [a], Tine Boiy [a], Elisabeth LIM Duval [b], Koenraad Van Hoeck [c]

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

milou.blits@uza.be

## Keywords

Children; fluids ; maintenance ; intravenous.

## Abstract

### Objective

Prescribing intravenous maintenance fluids is daily practice for many pediatricians. In 2018, the American Association of Pediatrics published the first evidence-based clinical practice guideline on this topic, but many pediatricians have not incorporated it into their clinical practice. To pursue safety in prescribing intravenous maintenance fluids, a standardization of care is wise. We aim to describe the current practice in Belgium to evaluate the need for further local guidelines.

### Methods

We conducted a cross-sectional electronic survey of pediatricians currently working in a Belgian pediatric ward. The survey consisted of general questions about prescribing habits and questions about two specific cases.

### Results

122 respondents completed the survey. There is a wide variation in baseline checks before starting fluids, and electrolyte monitoring during maintenance intravenous fluid administrations is not regularly performed in 43%. The Holiday and Segar formula, used by 102 respondents, remains the most popular method of calculating the rate, although many respondents use different methods depending on the case. The type of solution used is also very variable with 18 different fluids mentioned, much depending on the case.

### Conclusion

A great variety in type and rate exists in the prescription of intravenous fluids as well as differences in monitoring. Our results show that pediatricians tailor IV fluids to each case and deviate from their own protocol in many cases. While a strict protocol may prove difficult, a guidance through the important considerations and current literature may well be a valuable addition to promote safety in prescribing intravenous maintenance fluids.

## Introduction

### Background and relevance of the study

A large amount of intravenous (IV) fluids is prescribed daily for hospitalized children for various reasons. Although guidelines for fluid resuscitation and rehydration have become increasingly available, literature and guidelines on the type and the best way to prescribe IV maintenance fluid (IV-MF) remain scarce. The European Society of Pediatric and Neonatal Intensive Care (ESPNIC) defines IV-MF as "*the water and electrolyte prescription designed to replace anticipated physiologic water and electrolyte losses over the ensuing 24-h period*" (1). However, there are numerous interpretations of what constitutes IV-MF, evident from the various definitions found in literature. These definitions sometimes encompass rehydration or aim at correcting electrolyte imbalances. Such diversity makes it challenging to conduct high-quality trials or reviews.

The optimal tonicity of IV-MF has also been a subject of debate. Tonicity affects extracellular fluid osmolality: hypertonic solutions cause cells to shrink, hypotonic solutions cause swelling, and isotonic solutions maintain cell size. Historically, hypotonic solutions were used as IV-MF. Since the late 1990s, an increased number of reports were published questioning the use of hypotonic solutions due to the risk of iatrogenic hyponatremia, hyponatremic encephalopathy or even death (2, 3). Multiple RCT's and meta-analyses have described higher incidences of hyponatremia in hypotonic IV-MF compared to isotonic IV-MF (4-6).

In 2018, the American Academy of Pediatrics (AAP) published a guideline on IV-MF recommending that "*patients 28 days to 18 years of age requiring maintenance IVFs should receive isotonic solutions with appropriate potassium chloride and dextrose because they significantly decrease the risk of developing hyponatremia*" (7). While this statement is generally accepted, many pediatricians have yet to incorporate it into their clinical practice (8, 9).

There has been even more discussion about the need for balanced solutions (with electrolyte content approaching that of plasma). In adults NaCl 0.9%, an unbalanced solution, can cause hyperchloremic acidosis, hyperkalemia and acute kidney injury (AKI). Literature in children is sparse, but the use of balanced solutions in resuscitation results in less acidosis, shorter length of stay (LOS), and faster normalization of pH in diabetic ketoacidosis (10-12). When used for maintenance, some studies support balanced fluids, while others could not show significant clinical differences (13-15). However, given that NaCl 0.9% could lead to hyperchloremic acidosis, AKI, hyperkalemia, hypertension, inflammation, and coagulopathy, it is advisable to use alternative products (4). Similar discussions surround the optimal potassium content, but confirmatory evidence on this topic remains scarce (16).

The Holliday and Segar (H/S) formula, published in 1957, has been widely used to calculate the rate of IV-MF (17). Although alternative methods were developed later, none have surpassed its popularity (18). However, because the H/S formula is based on caloric expenditure in healthy

children, it often overestimates actual fluid needs (19). This limitation was noted in studies of children admitted to pediatric intensive care units (PICU's), where recommendations to restrict the rate to, for example, 50-80% have been made (1).

### *Aim*

Aiming to create national guidance for the prescription of IV-MF, the Be-PIV research group developed a survey to assess current daily practices in various hospitals across the country. This survey covers both the description of the most used fluid compositions and the methods used for calculating the rate of administration.

## Methods

### *Study design and methods*

We conducted a cross-sectional electronic survey among pediatricians and pediatric residents currently working in Belgian pediatric wards. Our aim was to target pediatricians working with non-critically ill children aged 1 month to 16 years. Clinical practices in neonatal (intensive care) units (NICU's), and PICU's were excluded.

According to the National Institute for Health and Disability Insurance (RIZIV/INAMI), there were 508 pediatric residents and 2154 licensed pediatricians registered as of March 2023. However, not all of them are actively working in hospitals. Therefore, we compiled a list of pediatric wards obtained from the Federal Public Service of Health and researched each pediatric team online. This yielded a total of 997 pediatricians working in pediatric wards, with 350 in the Flemish region, 256 in Brussels, and 391 in the Walloon region.

### *Survey development*

The survey was crafted following extensive review of current literature and modeled after the recently published survey of ESPNIC (8). To mitigate responder bias and confirm demographic diversity, the first part of the survey included questions about the respondent's hospital type and personal function. The second part comprised general queries on fluid prescriptions and two specific cases (Box 1 and Box 2). These cases provided a broad description of common pediatric ward pathologies and served to confirm the general approach indicated in the earlier section.

**Box 1**: Case description.

| | |
|---|---|
| **Holliday-Segar's** *formula*<br>*Based on weight* | 1-10 kg = 100 mL/kg/day<br>11-20 kg = 1000 mL + 50 mL/kg>10kg/day<br>>20 kg = 1500 mL + 25 mL/kg>20kg/day |
| **Oh's** *formula*<br>*Based on weight* | 1-10 kg = 4 mL/kg/hour<br>11-20 kg = 40 mL + 2 mL/kg>10kg/hour<br>>20 kg = 60 mL + 1 mL/kg>20kg/hour |
| **Adelman-Solhaug** *formula*<br>*Based on body surface area* | 1500 mL/m²/day |
| **Neonate/infant**<br>*Different variations*<br>*Based on weight and/or months of age* | *Example*<br><6 kg = 150 mL/kg/day<br>6-8 kg = 125 mL/kg/day<br>8-10 kg = 100 mL/kg/day |

**Box 2**: Common formula's for calculating infusion rate.

| | |
|---|---|
| **Case 1** | 14-year-old boy (50 kg, 180 cm) admitted for elective thoracic surgery for a pectus excavatum (NUSS-bar).<br>Postoperative nausea despite medication.<br>Does not tolerate nasogastric tube feeding. |
| **Case 2** | 8-week-old infant (4.5 kg).<br>Admitted to general ward with bronchiolitis and 1L/min O2.<br>Parents refuse nasogastric tube. |

Questions were presented in both multiple-choice and free-text formats to facilitate descriptive analysis and gather free-form suggestions.

Accompanying the survey was an informative text explaining the survey's objective. Completion of the survey was considered implicit consent to participate in the study. The survey was drafted in English to encourage a higher response rate across all regions of Belgium.

Full access to the survey is available upon request.

### *Data collection*

The electronic survey was conducted online using Jotform software from March to May 2023. It was first introduced at the Congress of the BVK-SBP (Belgische Vereniging voor Kindergeneeskunde – Société Belge de Pédiatrie) in March 2023. Subsequently, several follow-up emails were sent to the entire network of the VVK (Vlaamse Vereniging voor Kindergeneeskunde), SFP (Société Française de Pédiatrie), and the BAoP (Belgian Academy of Paediatrics). A final reminder was sent by contacting the secretaries of all pediatric wards in Belgium. Only fully completed surveys were considered eligible for analysis.

### *Data analysis*

The data were imported into Excel for further descriptive analysis. Multiple-choice answers are presented as percentages. Characteristics of respondents (position, type of hospital employment, etc.) were only utilized for descriptive analysis.

## Results

### *Participants*

One hundred and twenty-two respondents completed the survey resulting in a response rate of 12%. While our numbers may be low, the structure of our survey allows for responses to be entered from a hospital unit rather than an individual. One-third of respondents report working primarily in a university hospital while the remainder work in regional hospitals. Of these, 79% indicate report working with residents, with the remaining 21% working without residents (Figure 1).

Respondents' roles were evenly distributed among pediatric residents, general pediatricians, and pediatric subspecialists, with 39%, 33%, and 26%, respectively. In addition, 2% of respondents are currently completing a pediatric fellowship (Figure 2). Years of experience in pediatrics ranged from 3 to 30 years.

### *Protocols and check ups*

Of all respondents, 65% claim that some form of guideline, protocol, or agreement is available in their hospital for the prescription of IV-MF.

Before starting IV-MF, 82% check baseline electrolytes, glycemia, and/or kidney function, while 18% do not. Follow-up check-ups are not regularly done in 43% of cases. The remaining respondents have a variable method of follow-up, ranging from once a week to daily, depending on baseline values or underlying conditions.

More than half of the respondents report that patients on IV-MF are weighed daily, while 9% do not monitor the patients' weight. In 38% of responses, some form of fluid balance is monitored. However, what is used to calculate the fluid balance varies significantly. Some respondents only consider enteral intake, continuous IV fluids, diuresis, and stools, while others also include the volume of medication, flushes and sometimes an estimation of the insensible losses.

### *Volume and rate*

The most used formulas to calculate the rate of infusion of MF are described in Box 1. The preferences for these formulas are illustrated in Figure 3. H/S formula is the most frequently used method for prescribing the rate of infusion (102 out of 122 respondents). Among these, 37 respondents use only the H/S formula, while 7 use only Oh's formula and 3 use

**Figure 1**: Type of hospital in which the respondent mainly works.

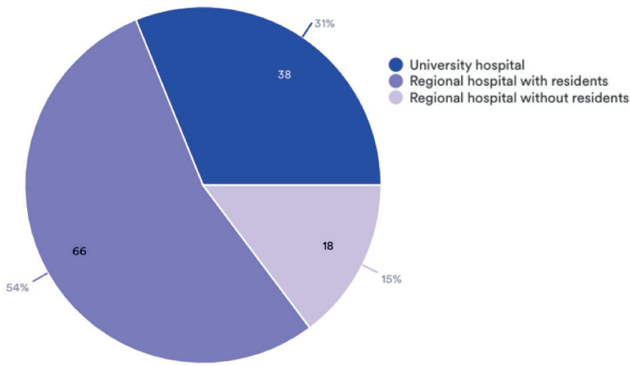



**Figure 2**: Respondents' level of training

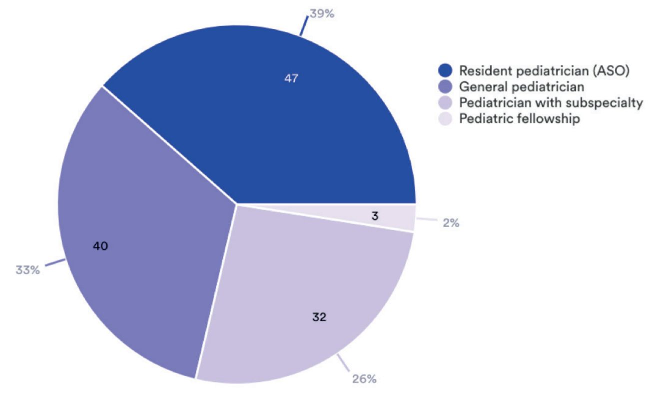
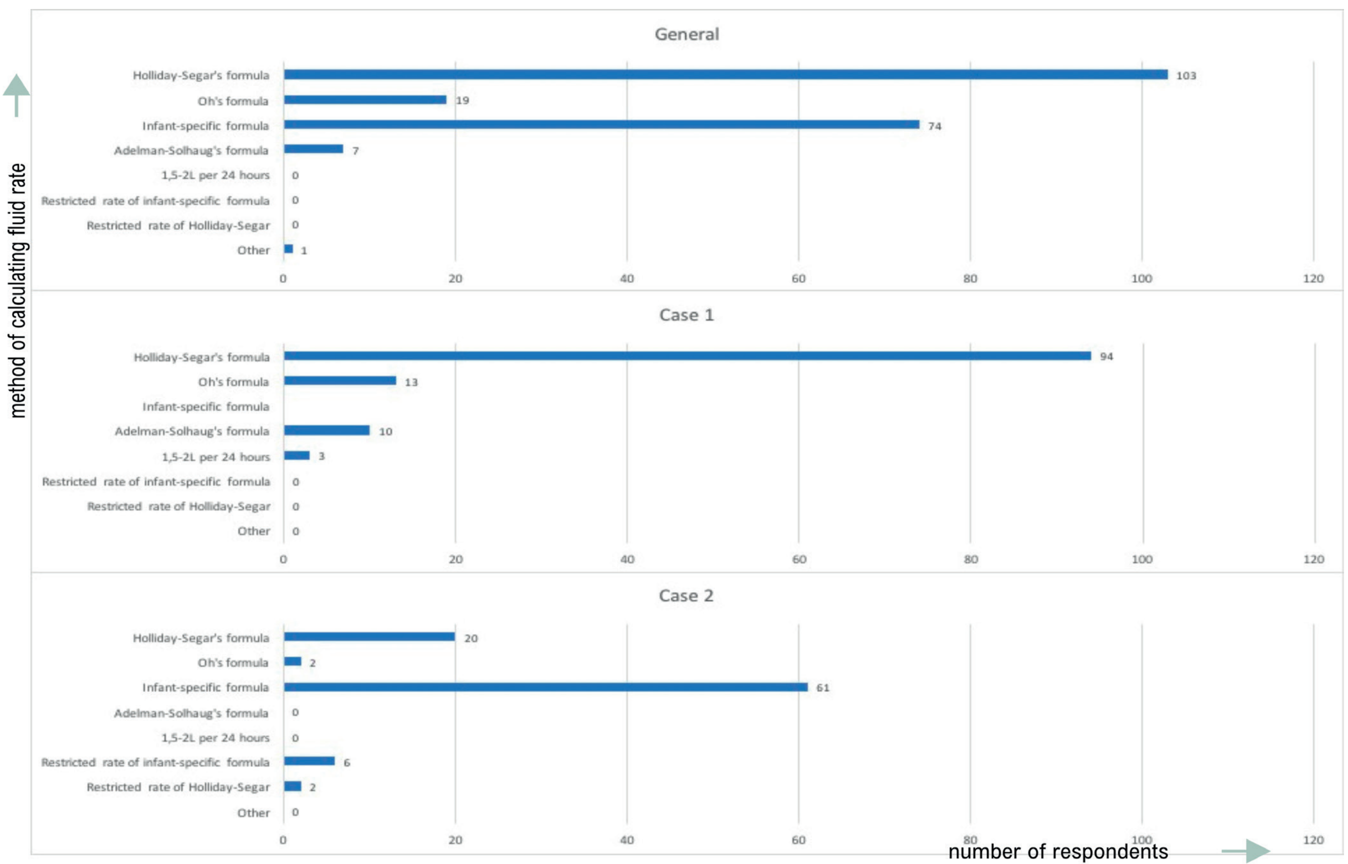



**Figure 3**: Number of respondents' answers to 'What method of calculating the rate of IV-MF do you use in general (top), in case 1 (middle), and in case 2 (bottom).' The x-axis displays the absolute number, while the y-axis represents the different possibilities.




only Adelman-Solhaug's (A/S) formula. Additionally, 69 respondents use a combination of methods depending on the age of the patient, with a variation of the method described in Box 1 being the most common alternative. Few other calculation methods outside of the ones described earlier are used.

When presented with a specific case (Box 2), multiple respondents deviated from their original answers regarding the prescription of MF (Figure 4).

In Case 1, concerning a teenager after elective surgery, only four respondents would not start IV-MF in the first place. The H/S formula remains the most widely used, with 93 out of 118 responses. Out of seven respondents that claim to use A/S method, only five would use it in this case. Additionally, six respondents who initially stated they only use the H/S formula switch to A/S formula in this case. Three respondents would consider the case as that of an adult patient and would prescribe 1.5-2L per 24 hours. Among the four respondents not starting IV-MF, one would immediately start total parenteral nutrition, while the other three would attempt a combination of anti-emetics and oral rehydration salts.

In case 2, the answer of 90 respondents showed a broad variation in rate calculation.

Among the 56 respondents who initially stated the use of infant-specific formula in infants in the general part, eight used H/S formula in this case. Additionally, 19 respondents who claimed in the general question that they do not use a specific infant-based formula switched to this option when given this specific case. In total, only seven respondents restricted fluid in this case due to the risk of increased ADH secretion.

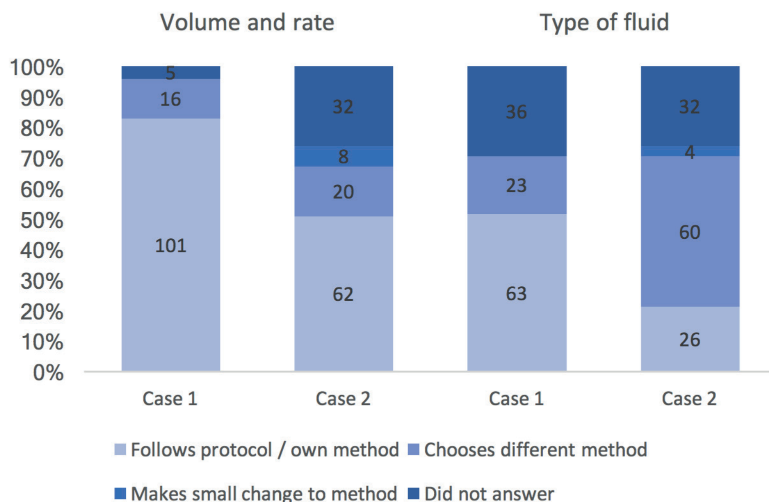



**Figure 4**: Deviations from general protocol per case in terms of calculation of rate and volume (left) and type of solution.

### *Type of fluid*

A wide variety of solutions is used as IV-MF, with the content and characteristics described in Table 1. Generally, more than half of the fluids (52%) frequently used as IV-MF are hypotonic. The choice of fluid differs considerably when asked in general compared to when asked in the context of a specific case. In case 1 and case 2, 49% and 42% of respondents respectively claim to use some type of hypotonic solution. As evidenced by the differences in answers between the general question and the cases, respondents deviate from their own protocol in 19% and 52% respectively in case 1 and case 2. Figures 4 and 5 illustrate these differences.

More than half of the respondents say they don't calculate sodium or potassium requirements in both cases. Only 16% and 30% calculate the glucose requirement in case 1 and 2 respectively.

In specific cases, such as the follow-up question in case 2 where the infant presents with hyponatremia, 80% of respondents will deviate from their usual IV fluid prescription protocol.

## Discussion

The survey highlights the inherent complexity involved in prescribing IV-MF for the pediatric population. Pediatricians must consider various factors such as the patient's age, weight, underlying pathology, and baseline evaluations.

The implementation of existing guidelines in specific clinical cases, as revealed in this survey, was rather low: in 72% of the cases hypotonic fluids were still used. Almost 97% of the respondents used the correct rate in older children, but only 24% in neonates. Only a fraction of the respondents correctly decreased the rate when there were signs of increased ADH secretion.

The reasons for this were not always clear. Perhaps it is a lack of awareness due to insufficient dissemination of guidelines, or a lack of understanding of the rationale behind the guidelines and how to apply them in specific contexts. In addition, respondents' personal preferences may have conflicted with the guidelines, or deviations from the guidelines may have been based on clinical assessments of the child. While it was beyond the scope of this survey to explore the motivations for adopting a different approach, it led us to question the feasibility of strict national guidelines.

A crucial aspect of safely prescribing IV-MF, given its nature as a drug, is establishing a correct definition, correct target group and correct indications. Our literature review revealed a lack of consensus on the definition of MF, making it challenging to compare different protocols and assess adherence to guidelines. The definition of IV-MF used in this study focused on temporarily substituting fluids and electrolytes to maintain homeostasis when the child was unable to receive maintenance fluids enterally (which remains the

**Figure 5**: Number of respondents' answers to 'What type of solution do you use as MF in general (top), in case 1 (middle), and in case 2 (bottom).' The y-axis displays the absolute numbers, while the x-axis represents the different possibilities.

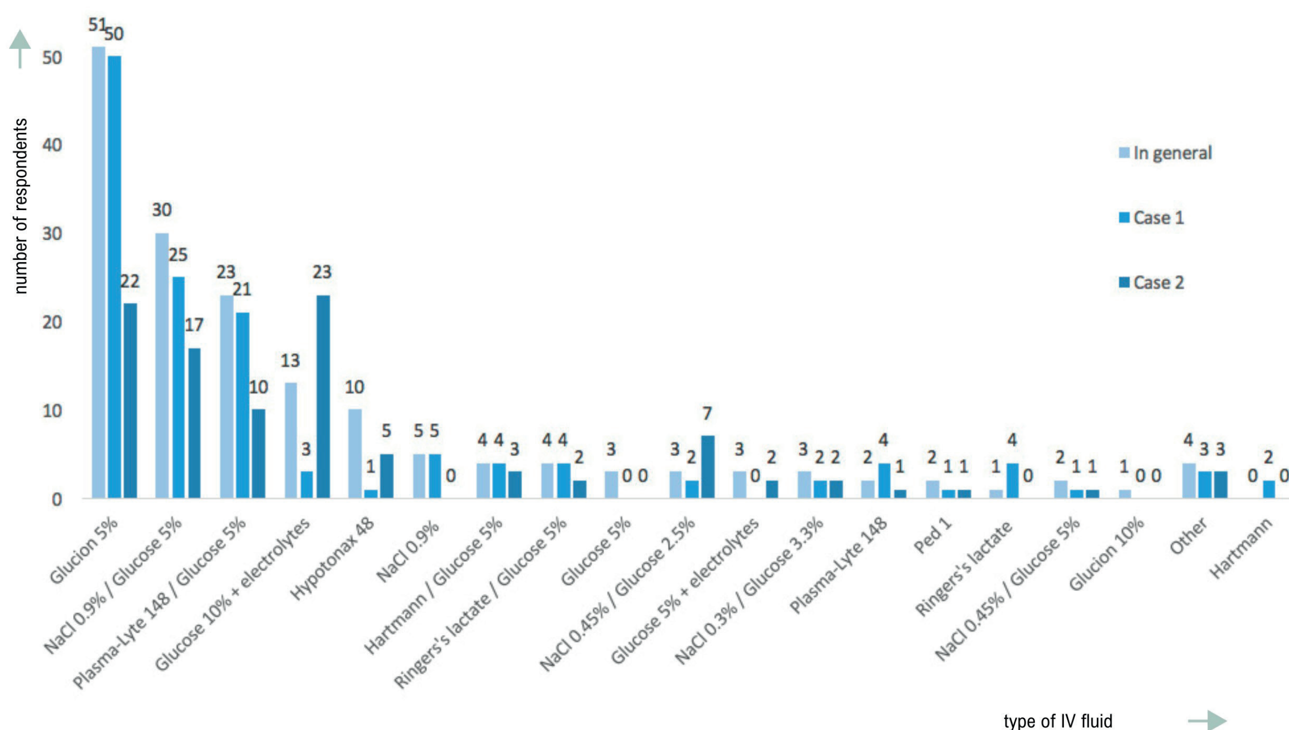


**Table 1**: Content and characteristics of different types of fluids. (*) depending on electrolytes.

| TRADE NAME OF FLUID | TONICITY | BALANCED | OSMOLARITY (MOSM/L) | NA+ (MMOL/L) | K+ (MMOL/L) | GLUCOSE |
|---|---|---|---|---|---|---|
| Glucion 10% | Hypotonic | No | 725 | 54 | 26 | Yes |
| Glucion 5% | Hypotonic | No | 447 | 54 | 26 | Yes |
| Glucose 10% + electrolytes | * | No | * | * | * | Yes |
| Glucose 5% | Hypotonic | No | 278 | 0 | 0 | Yes |
| Glucose 5% + electrolytes | * | No | * | * | * | Yes |
| Hartmann | Isotonic | Yes | 278 | 131 | 5 | No |
| Hartmann / Glucose 5% | Isotonic | Yes | 555 | 131 | 5 | Yes |
| Hypotonax 48 | Hypotonic | Yes | 372 | 25 | 5 | Yes |
| NaCl 0.3% / Glucose 3.3% | Hypotonic | No | 285 | 51 | 0 | Yes |
| NaCl 0.45% / Glucose 2.5% | Isotonic | No | 293 | 77 | 0 | Yes |
| NaCl 0.45% / Glucose 5% | Hypotonic | No | 432 | 77 | 0 | Yes |
| NaCl 0.9% | Isotonic | No | 308 | 0 | 0 | No |
| NaCl 0.9% / Glucose 5% | Isotonic | No | 585 | 154 | 0 | Yes |
| Ped 1 | Isotonic | Yes | 420 | 41 | 30 | Yes |
| Plasma-Lyte 148 | Isotonic | Yes | 296 | 140 | 5 | No |
| Plasma-Lyte 148 / Glucose 5% | Isotonic | Yes | 572 | 140 | 5 | Yes |
| Ringer's Lactate | Isotonic | Yes | 278 | 131 | 5 | No |

preferred method). In case 2, the indication for IV-MF was questioned, given the consensus and recommendation to prioritize enteral feeding whenever feasible (20). Although choosing not to initiate IV-MF was an option provided to respondents, deviations from their own protocols may partly stem from this uncertainty regarding the indication. An IV-MF is also not intended to correct fluid or electrolyte imbalances. In cases where correction is needed, a patient-tailored approach will be needed.

As mentioned earlier, hospitalized children often have different caloric expenditure and therefore different volume needs compared to healthy children. Several factors contribute to this variability. For instance, increased water loss may occur due to conditions such as burns, fever, gastrointestinal losses, excessive sweating, and polyuria. Conversely, patients with kidney failure may exhibit decreased urinary output. Moreover, there are numerous instances where the body's normal regulatory mechanisms for maintaining homeostasis are compromised. This is particularly relevant for children admitted to hospitals, as various non-osmotic factors can influence ADH-secretion, including nausea, pain, stress, central nervous system disturbances, or pulmonary disease. In such cases, it may be necessary to implement a relative fluid restriction compared to what is calculated by the H/S formula.

There are some limitations to our study. Our response rate was not high, but it is very difficult in Belgium to obtain exact data on the number of pediatricians actively working in hospitals. Relying on hospital websites might have both overestimated or underestimated our numbers. Due to the voluntary nature of this survey, it is also more likely that pediatricians with a greater interest in this topic would have responded, which makes it impossible to avoid respondent bias. Consequently, we were unable to reliably determine if our sample was truly representative of Belgian pediatricians working in a hospital setting.

We did not ask respondents to indicate their region of activity, so we were unable to distinguish between Flemish- or Walloon-trained pediatricians, which might have provided means of identifying regional variations in practice.

Furthermore, one might argue that due to the frequency with which pediatricians prescribe IV-MF, guidelines may not always be consulted. It remains unclear whether factors such as tonicity or anions in IV-MF are consistently considered by all pediatricians. Given the diversity of literature on these topics, keeping up to date is a challenge.

## Conclusion

In this survey on the use of IV-MF, we investigated the availability of protocols and local practices among Belgian pediatricians. We found a wide variety in the choice of fluid types and observed a low adherence to existing guidelines.

The lack of high-quality studies and reviews on the type and rate of IV-MF indicates that there is probably no simple solution for a ‘one size fits all’ approach. Pediatricians customize their method of prescribing IV-MF based on factors such as the patient's weight, age, and current health status.

Setting up a high-quality clinical trial in which pediatricians would have to adhere to a strict protocol of IV-MF to confirm or disprove certain differences in rate and content is no easy task. However, it's crucial to recognize that IV fluids are medications and should be treated as such. This entails clear consideration of the indication, baseline assessment at the outset, monitoring of effects, and regular reassessment of the need for continued treatment.

In this regard, a consensus recommendation that guides Belgian pediatricians through important considerations could be highly valuable. By providing an easy-to-follow approach and summarizing key findings from recent high-quality literature, both young and experienced pediatricians can make evidence-based decisions.

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X. Beretta-Piccoli, Department of Intensive Care, Hôpital Universitaire des Enfants Reine Fabiola, Brussels, Belgium.

M. Blits, T. Boiy, M. Van Oort, Department of Pediatrics, Antwerp University Hospital, Antwerp University Hospital, Antwerp, Belgium.

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.


### *DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST*

None of the authors has a conflict of interest to declare.

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