Polish Annals of Medicine

Journal homepage: https://www.paom.pl

Research paper

Fluid therapy in pyloric stenosis – assessment of the implementation of hospital guidelines

Magdalena Lewandowska, Paweł Polityło, Przemysław Przewratil

Department of Paediatric Surgery and Oncology, Central University Hospital, Medical University of Lodz, Poland

Article info

Article history
Received: February 22, 2021
Accepted: May 6, 2021
Available online: November 16, 2021

Keywords
Fluid therapy
Pyloric stenosis
Hospital guidelines
Control audit

Doi
https://doi.org/10.29089/2021.21.00200

Abstract

Introduction: The preoperative correction of the hypochloremic, hypokalemic metabolic alcalosis in children with infantile hypertrophic pyloric stenosis (IHPS) is essential to optimal outcome.

Aim: The main aim of the study was the assessment of the implementation of hospital guidelines for intravenous fluid therapy in children with IHPS.

Material and methods: In our Department, at the beginning of 2018 hospital guidelines for intravenous fluid therapy in children were implemented. Two internal audits were performed and surgeons' compliance with the current recommendations was evaluated. We assessed: the type of fluid transfused, a rate of transfusion and whether saline bolus was given. The study group consisted of 50 patients.

Results and discussion: After new guidelines were implemented, appropriate iv fluid was given to 68.7% of children compared to 5.1% before implementation ($P = 0.0001$). Proper transfusion rate was used in 44.1% of patients before introduction of new guidelines and in 81.2% after that ($P = 0.01$). Second audit showed that all children had received the recommended iv fluid ($P = 0.007$) at a good transfusion rate ($P = 0.02$). In patients who had received the recommended iv fluid, the length of hospital stay after surgery ($P = 0.023$) and the total length of stay ($P = 0.018$) were shorter.

Conclusions: The new guidelines have raised the level of the whole care for children with pyloric stenosis. The internal audits played an important role in their implementation.

Corresponding author: Magdalena Lewandowska, Department of Paediatric Surgery and Oncology, Central University Hospital, Medical University of Lodz, Sporna 36/50, Łódź 91-738, Poland. E-mail address: magdalena.anna.lewandowska@umed.lodz.pl.

1. INTRODUCTION

Hospital guidelines are useful tools that synthesize and translate into clinical practice current evidence based knowledge for a given clinical problem. They serve as the basis for treatment evaluation and if routinely audited, allow for quality improvement. Implementation process takes time and depends on awareness and acceptance levels of the medical staff.

Infantile hypertrophic pyloric stenosis (IHPS) is one of the most common surgical condition of the infant characterized by an acquired narrowing of the pyloric channel. Typically IHPS manifests between 2 and 8 weeks of age with postprandial, projectile, nonbilious vomiting as a classic symptom. Vomiting of gastric contents leads to depletion of sodium, potassium, chloride and hydrogen ions, eventually resulting in the classical hypochloremic, hypokalemic metabolic alkalosis. IHPS is not a surgical emergency and should only undergo operative intervention once the patient is adequately resuscitated. The aim of the resuscitation is to correct these electrolyte derangements.[1,2] Severe metabolic alkalosis can be potentially life-threatening. It can affect the respiratory drive of an infant and has been associated with apneas and extubation difficulties after surgery. Furthermore, the degree of metabolic alkalosis at presentation correlates to the number of episodes of postoperative emesis, as well as time to goal feeds and length of stay. In general, to correct alkalosis 5%–10% glucose in 0.45% or 0.9% sodium chloride and 10–20 mmol/L of potassium chloride is administered at a rate of 150 mL/kg daily. Profoundly dehydrated patients with oliguria require an initial fluid bolus of 20 mL/kg of 0.9% saline. Potassium is usually withheld until oliguria is corrected after saline boluses.[3,4] Only when serum bicarbonate (the goal is to decrease the level below 30 mEq/dL), serum potassium, sodium and chloride are corrected, performing anaesthesia and surgery is safe.[5] Therefore, adequate fluid resuscitation in patients with IHPS plays a key role in preparation for general anaesthesia and surgery.

2. AIM

The main aim of the study was the assessment of the implementation of hospital guidelines for i.v. fluid therapy in children with pyloric stenosis. In addition, the impact of appropriate fluid therapy on the time of the preparation for surgery, postoperative vomiting, the length of hospital stay after surgery and total length of hospital stay were assessed.

3. MATERIAL AND METHODS

In our Department, until 2018, there was no intravenous fluid therapy protocol for children with IHPS. There were several treatment regimens used by surgeons at their discretion and experience. Most often surgeons administrated one of the following fluids: commercially available 2.5% glucose in 0.45% NaCl, 3.3% glucose in 0.3% NaCl or component fluid being a prepared mixture of 5% glucose, 10% glucose, 10% NaCl, 15% KCl, calcium and magnesium ions and sometimes even with the addition of amino acids. The concentration of ions and glucose in those mixtures varied widely.

At the beginning of 2018 hospital guidelines for i.v. fluid therapy in children were developed and implemented. They were based on: NICE-Guideline (NG29), Clinical Practice Guideline from the American Academy of Pediatrics, anaesthesiology books (*Smith's Anesthesia for Infants and Children*, *Neonatal Anesthesia* of J. Lerman editor) and review of current literature. For children with IHPS the hospital guidelines recommended:

- 10% glucose with 0.9% NaCl in equal volumes (there is no commercially available fluid of 5% glucose in 0.45% or 0.9% saline on the Polish market) plus 1 mL of 15% KCl (2 mmol K^+) for every 100 mL of the solution at a rate 150 mL/kg daily (if $HCO^{3-} \geq 30$ mmol/L) or 120 mL/kg dailyy (if $HCO^{3-} < 30$ mmol/L);
- if the patient is dehydrated on admission (this applies to most of children), a 20 mL/kg of 0.9% NaCl bolus should be given.

Fourteen months after introduction of the new guidelines, an internal audit was performed and surgeons' compliance with the current recommendations was assessed. The next review of the fluid resuscitation in patients with pyloric stenosis was performed at the end of 2019. We assessed: the type of fluid transfused, the rate of transfusion and whether saline boluses were given.

All patients were divided in two groups: before and after introduction of the new guidelines. In both groups we examined, if the patients received the appropriate – compatible with the recommendations, iv fluid for pyloric stenosis. In addition, in all patients treated with appropriate and inappropriate fluid therapy – also in the period before the introduction of the guidelines, we analysed: the time from admission to surgery, the occurrence of vomiting in the postoperative period, the length of hospital stay after surgery and total length of hospital stay.

The charts of 50 patients treated for pyloric stenosis at the Department of Paediatric Surgery and Oncology of Central University Hospital of Medical University of Lodz from January 1, 2014 to the end of 2019 were reviewed. The group of 34 children were treated before the introduction of the new guidelines and 16 children after that. From the second group 8 patients were treated before the first audit and 8 after that. For each patient, the following information was recorded: age, weight, gender, type of fluid therapy, rate of transfusion, time to surgery, postoperative vomiting, length of hospital stay after surgery and total length of hospital stay.

All values for continuous variables were summarized as mean ± standard deviation (SD) and median (M). The Shapiro–Wilk test was used to check the normality of the distribution of the examined feature. To compare the two independent variables the Mann–Whitney U test was applied and the ANOVA Kruskal–Wallis test – for many independent trials. The correlation is shown by the χ^2 test of independence. The difference was considered statistically significant at P value less than 0.05.

4. RESULTS

The demographic data: age, weight and male to female ratio in two groups, before and after introduction of new hospital guidelines, are presented in Table 1.

Before introduction of the new hospital guidelines, appropriate iv fluid for pyloric stenosis was used in only 5.9% of patients. Inappropriate iv fluid, one of 5 types of fluid: 2.5% glucose in 0.45% NaCl, 3.3% glucose in 0.3% NaCl, component fluid, 5.0% or 10.0% glucose, balanced electrolyte solution with 1.0% glucose (BS-G1), was used in 94.1% of patients. After the new guidelines were implemented, appropriate iv fluid was given to 68.7% of children treated for pyloric stenosis ($P = 0.0001$). Proper transfusion rate was used in 44.1% of patients before introduction of the new guidelines and in 81.2% after that ($P = 0.01$) (Table 2). In addition, none of children had received a 0.9% NaCl bolus, prior to introduction of new hospital guidelines.

In the period after the introduction of the new guidelines, it is evident progress among surgeons in the use of recommended fluid therapy. The impact of the internal audit on compliance with the new guidelines is shown in Table 3. Prior to the follow-up audit, 37.5% of patients had the correct i.v. fluid compared to 100% children after the audit ($P = 0.007$). The transfusion rate was correct in 63.0% of patients before the audit and in 100.0% of them after that ($P = 0.02$). In addition, 0.9% NaCl bolus was given to 25% of patients before and 50.0% of patients after the audit, but the difference was not significant ($P = 0.2$).

We observed, that in the group of patients after implementation of the guidelines significantly shorter were: the hospital stay after surgery – 2.81 ± 1.68 days, M = 3 vs. 4.24 ± 1.74, M = 4 before ($P = 0.0008$) and the total length of stay – 3.88 ± 1.71 days, M = 4 vs. 6.29 ± 3.66, M = 6 before ($P = 0.001$).

In the entire study group of 50 children (before and after introduction of the guidelines), appropriate iv fluid was used in 13, and inappropriate in 37 patients. In patients who had recommended for pyloric stenosis iv fluid mean preparation time to surgery was shorter: 22.46 ± 8 h ($P = 0.6$). In this group of children, the length of hospital stay after surgery ($P = 0.023$) and the total length of stay ($P = 0.018$) were also shorter. The incidence of postoperative vomiting was lower in patients treated with recommended fluid therapy: 46.1% vs. 56.8% – it was not a significant difference ($P = 0.5$). Effects of intravenous fluid therapy are presented in Table 4.

5. DISCUSSION

The implementation of the recommendations requires organised planning, effort to make all the users be aware of the new guidelines and accept them. As seen in our example, it can take many months to see the results. There are many barriers to introduce new guidelines into clinical practice. The main obstacles are habitual practice patterns, malpractice fears, information overload, and fear of diminished professional autonomy.[6]

The goal of the introduction of iv fluid therapy recommendations for patients with pyloric stenosis was to provide the same regimen, that was developed based on approved books and the latest reports from the literature. Once a year, the recommendations were reviewed and possibly supplemented with new, relevant information. Internal audits proved to play very important role for implementing the recommendations. They are carried out every few months, depending on the number of patients treated in a given period of time. They

Table 1. Demographic data.

	Before recommendations $n = 34$	After recommendations $n = 16$
Age, mean ± SD (M), days	36.53 ± 14.03 (34)	47.81 ± 27.92 (45)
Weight, mean ± SD (M), kg	3.83 ± 0.60 (4)	3.94 ± 0.79 (4)
Male to female ratio	7.5 : 1.0	15.0 : 1.0

Table 2. Type of iv fluid and transfusion rate.

	Before recommendations $n = 34$	After recommendations $n = 16$	P value
Appropriate iv fluid	2 (5.9%)	11 (68.7%)	0.0001
Inappropriate iv fluid:	32 (94.1%)	5 (31.3%)	
2.5% glucose and 0.45% NaCl	8	2	
3.3% glucose and 0.3% NaCl	9	–	
Component fluid[a]	10	1	
5% or 10% glucose	5	–	
BS-G1[b]	–	2	
Proper transfusion rate	15 (44.1%)	13 (81.2%)	0.01

Comments: [a] Prepared mixture of 5% and 10% glucose with 10% NaCl, 15% KCl, calcium and magnesium ions; [b] Balanced electrolyte solution with 1% glucose.

Table 3. Compliance with new guidelines – after recommendations.

	Before audit $n = 8$	After audit $n = 8$	P value
Appropriate iv fluid	3 (37.5%)	8 (100%)	0.007
Correct transfusion rate	5 (63%)	8 (100%)	0.02
Bolus of 0.9% NaCl	2 (25%)	4 (50%)	0.2

Table 4. Effects of correct i.v. fluid choice, mean ± SD (M).

	Appropriate i.v. fluid $n = 13$	Inappropriate i.v. fluid $n = 37$	P value
Time to surgery, mean ± SD (M), h	22.46 ± 8 (21)	34.05 ± 32 (22)	0.6
Postoperative vomiting, number of patients (%)	6 (46.1%)	21 (56.8%)	0.5
Length of stay after surgery, mean ± SD (M), days	3.00 ± 2 (3)	4.05 ± 2 (4)	0.023
Total length of stay, mean ± SD (M), days	4.08 ± 2 (4)	6.03 ± 4 (5)	0.018

show how much has been achieved so far and what mistakes are still being made, explain the doubts arising during the application of the recommendations. They have a great training and motivating impact. In the presented group of patients, all treated after internal audit received fluid therapy in accordance with the recommendations.

Introduction of the recommendations improves patient care because it reduces the risk of making mistakes and makes it easier to identify, verify and fix the mistake. In addition, it facilitates comparison and evaluation of treatment results. In our opinion, the introduction of the guidelines for iv fluid therapy had a beneficial effect on monitoring of the entire course of treatment of children with IHPS, including: interpretation of laboratory tests, verification of the need to order control tests and ensuring strict compliance with the postoperative feeding regimen. Therefore, the hospitalization time after surgery and the total length of stay significantly shortened after the implementation of hospital guidelines.

The knowledge of biochemical abnormalities in children with pyloric stenosis and understanding the importance of fluid resuscitation prior to intervention is well documented. Intravenous fluid therapy in pyloric stenosis must correct metabolic alkalosis, which increases the risk of apneas in the postoperative period.[3,7–9] It should provide the right amount of sodium so as not to lead to postoperative hyponatremia with all its consequences (including vomiting). Because of the high risk of hypoglycemia in infants, it should also provide enough glucose.[10,11] Bolus of 0.9% NaCl treats dehydration and compensates for Cl^- deficiency.[12] Before the guidelines were introduced, the types of fluids used in our department did not meet all of the above-mentioned criteria simultaneously. No 0.9% NaCl bolus was administered and the fluids used contained either too little Na^+ (3.3% glucose in 0.3% NaCl, component fluid, 5% glucose or 10% glucose) or insufficient glucose (2.5% glucose in 0.45% NaCl, BS-G1).

If the recommended fluid therapy is used, there is no need to repeat the laboratory tests once the correct results have been achieved – which reduces the number of unnecessary, control tests.[13] Properly compensated deficiencies reduce the risk of alkalosis recurrence after surgery and postoperative hyponatremia. The preoperative preparation is essential to optimal outcome.[14] Proper hydration and stable electrolyte levels cause the organism to return to normal functioning faster. The hospitalization time after surgery, of the patients who were treated with the appropriate iv fluids, was shorter. They achieved ad libitum feeds faster than children with inappropriate iv fluids. The time from admission to surgery was on average shorter for these patients. Thus, the total length of stay in this group was also significantly shorter.

6. CONCLUSIONS

In summary, the implementation of the guidelines required organised planning, time, patience and commitment of all staff. The internal control audits played a big role in their implementation. The new guidelines for iv fluid therapy have raised the level of the whole care for children with pyloric stenosis in our institution.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics

This article does not contain any studies with human participants performed by any of the authors.

References

1 Koontz CS, WulkanIn ML. Lesions of the Stomach. In: Holcomb III GW, Murphy PJ, Ostlie DJ, eds. *Ashcraft's Pediatric Surgery*. 6th Ed. Elsevier Inc; 2014:403–407.

2 El-Gohary Y, Abdelhafeez A, Paton E, Gosain A, Murphy AJ. Pyloric stenosis: an enigma more than a century after the first successful treatment. *Pediatr Surg Int*. 2018;34(1): 21–27. https://doi.org/10.1007/s00383-017-4196-y.

3 Taghavi K, Powell E, Patel B, McBride C. The treatment of pyloric stenosis: Evolution in practice. *J Paediatr Child Health*. 2017;53(11):1105–1110. https://doi.org/10.1111/jpc.13736.

4 Jobson M, Hall NJ. Contemporary management of pyloric stenosis. *Semin Pediatr Surg*. 2016;25(4):219–224. https://doi.org/10.1053/j.sempedsurg.2016.05.004.

5 Peters B, Oomen MWN, Bakx R, Benninga MA. Advances in infantile hypertrophic pyloric stenosis. *Expert Rev Gastroenterol Hepatol*. 2014;8(5):533–541. https://doi.org/10.1586/17474124.2014.903799.

6 Gagliardi AR, Marshall C, Huckson S, James R, Moore V. Developing a checklist for guideline implementation planning: review and synthesis of guideline development and implementation advice. *Implement Sci*. 2015;12(2):10–19. https://doi.org/10.1186/s13012-015-0205-5.

7 Vinycomb TI, Laslett K, Gwini SM, Teague W, Nataraja RM. Presentation and outcomes in hypertrophic pyloric stenosis: An 11-year review. *J Paediatr Child Health*. 2019;55(10):1183–1187. https://doi.org/10.1111/jpc.14372.

8 Van den Bunder FAIM, van Wijk L, van Woensel JBM, Stevens MF, van Heurn LWE, Derikx JPM. Perioperative apnea in infants with hypertrophic pyloric stenosis: A systematic review. *Pediatric Anesthesia*. 2020;30(7):749–758. https://doi.org/10.1111/pan.13879.

9 van den Bunder FAIM, van Woensel JBM, Stevens MF, van de Burg T, van Heurn LWE, Derikx JPM. Respiratory problems owing to severe metabolic alkalosis in infants presenting with hypertrophic pyloric stenosis. *J Pediatr Surg*. 2020;55(12):2772–2776. https://doi.org/10.1016/j.jpedsurg.2020.05.041.

[10] Oh GJ, Sutherland SM. Perioperative fluid management and postoperative hyponatremia in children. *Pediatr Nephrol*. 2016;31(1):53–60. https://doi.org/10.1007/s00467-015-3081-y.

[11] Sümpelmann R, Becke K, Brenner S, et al. Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany. *Paediatr Anaesth*. 2017;27(1):10–18. https://doi.org/10.1111/pan.13007.

[12] Dalton BGA, Gonzalez KW, Boda SR, Thomas PG, Sherman AK, St. Peter SD. Optimizing fluid resuscitation in hypertrophic pyloric stenosis. *J Pediatr Surg*. 2016;51(8):1279–1282. https://doi.org/10.1016/j.jpedsurg.2016.01.013.

[13] Yanchar NL, Rangu S. Corrected to uncorrected? The metabolic conundrum of hypertrophic pyloric stenosis. *J Pediatr Surg*. 2017;52(5):734–738. https://doi.org/10.1016/j.jpedsurg.2017.01.024.

[14] Van den Bunder FAIM, Hall NJ, van Heurn LWE, Derikx JPM. A Delphi Analysis to Reach Consensus on Preoperative Care in Infants with Hypertrophic Pyloric Stenosis. *Eur J Pediatr Surg*. 2020;30(6):497–504. https://doi.org/10.1016/j.jpedsurg.2017.01.024.