Journal of Pediatric Surgery 51 (2016) 1279–1282

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Optimizing fluid resuscitation in hypertrophic pyloric stenosis

Brian G.A. Dalton [a], Katherine W. Gonzalez [a], Sushanth R. Boda [a], Priscilla G. Thomas [a], Ashley K. Sherman [b], Shawn D. St. Peter [a,*]

[a] Department of Pediatric Surgery, Children's Mercy Hospital, Kansas City, MO
[b] Department of Research Development and Clinical Investigation, Children's Mercy Hospital, Kansas City, MO

ARTICLE INFO

Article history:
Received 5 October 2015
Received in revised form 21 December 2015
Accepted 21 January 2016

Key words:
Hypertrophic pyloric stenosis
Electrolyte abnormalities
Fluid resuscitation
Chloride
Bicarbonate
Pyloromyotomy

ABSTRACT

Background: Hypertrophic pyloric stenosis (HPS) is the most common diagnosis requiring surgery in infants. Electrolytes are used as a marker of resuscitation for these patients prior to general anesthesia induction. Often multiple fluid boluses and electrolyte panels are needed, delaying operative intervention. We have attempted to predict the amount of IV fluid boluses needed for electrolyte correction based on initial values.

Methods: A single center retrospective review of all patients diagnosed with HPS from 2008 through 2014 was performed. Abnormal electrolytes were defined as chloride <100 mmol/L, bicarbonate ≥30 mmol/L or potassium >5.2 or <3.1 mmol/L. Patients with abnormal electrolytes were resuscitated with 20 ml/kg saline boluses and continuous fluids at 1.5 times maintenance rate.

Results: During the study period 542 patients were identified with HPS. Of the 505 who were analyzed 202 patients had electrolyte abnormalities requiring IV fluid resuscitation above maintenance, and 303 patients had normal electrolytes at time of diagnosis. Weight on presentation was significantly lower in the patients with abnormal electrolytes (3.8 vs 4.1 kg, $p < 0.01$). Length of stay was significantly longer in the patients with electrolyte abnormalities, 2.6 vs 1.9 days ($p < 0.01$). Fluid given was higher over the entire hospital stay for patients with abnormal electrolytes (106 vs 91 ml/kg/d, $p < 0.01$). The number of electrolyte panels drawn was significantly higher in patients with initial electrolyte abnormalities, 2.8 vs 1.3 ($p < 0.01$).

Chloride was the most sensitive and specific indicator of the need for multiple saline boluses. Using an ROC curve, parameters of initial Cl^- 80 mmol/L and the need for 3 or more boluses AUC was 0.71. Modifying the parameters to initial Cl^- ≤97 mmol/L and 2 boluses AUC was 0.65. A patient with an initial Cl^- 85 will need three 20 ml/kg boluses 73% (95% CI 52–88%) of the time. A patient with an initial Cl^- ≤97 will need two 20 ml/kg boluses at a rate of 73% (95% CI 64–80%).

Conclusion: Children with electrolyte abnormalities at time of diagnosis of HPS have a longer length of stay; require more fluid resuscitation and more lab draws. This study reveals high sensitivity and specificity of presenting chloride in determining the need for multiple boluses. We recommend the administration of two 20 ml/kg saline boluses separated by an hour prior to rechecking labs in patients with initial Cl^- value ≤97 mmol/L. If the presenting Cl^- <85 three boluses of 20 ml/kg of saline separated by an hour are recommended. If implemented these modifications have potential to save time by not delaying care for extraneous lab results and money in the form of fewer lab draws.

1. Background

Hypertrophic pyloric stenosis (HPS) is the most common diagnosis requiring surgery in infants. Electrolytes are used as a marker of resuscitation for these patients prior to general anesthesia induction. Typically, if electrolyte abnormalities (Cl^- <100 mmol/L, HCO_3 ≥30 mmol/L, or K^+ ≤3.4 or ≥5.2 mmol/L) are present on diagnosis of pyloric stenosis, aggressive intravenous fluid resuscitation is given. Often multiple electrolyte panels are needed to assess correction, delaying operative intervention. We have attempted to predict the amount of IV fluid resuscitation needed for electrolyte correction based on initial values. We hypothesized that patients with HPS and abnormal electrolytes would require more than standard fluid resuscitation to correct electrolytes prior to pyloromyotomy, and a review of retrospective data would be able to provide a starting point for a more efficient fluid resuscitation strategy.

2. Methods

After approval from the Children's Mercy Hospital Internal Review Board (IRB # 13070217) a single center retrospective chart review was performed. All patients diagnosed with HPS from 2008 through 2014 were considered. Patients were excluded for insufficient data in medical records, or if electrolyte abnormalities were atypical for HPS.

* Corresponding author at: Children's Mercy Hospital, Department of Surgery, 2401 Gillham Rd., Kansas City, MO 64108. Tel.: +1 816 983 6465; fax: +1 816 983 6885.
E-mail address: sspeter@cmh.edu (S.D. St. Peter).

http://dx.doi.org/10.1016/j.jpedsurg.2016.01.013
0022-3468/

Table 1
Demographic data.

	Abnormal electrolytes (n = 202)	Normal electrolytes (n = 303)	p
Age (weeks)	5.6	5.4	0.44
Gender (%male)	83	84	0.58
Weight (kg)	3.8	4.1	<0.01
Pylorus length (cm)	2.0	2.0	0.64
Pylorus diameter (cm)	0.4	0.4	0.19

Data are presented as mean ± standard deviation unless otherwise stated. Significance is defined as $p \le 0.05$. Comparative analysis was performed using Student *t* test for continuous variables and Fisher exact for binary variables or chi square test with Pearson correlation where appropriate. Area under the curve (AUC) was calculated using receiver operating characteristic (ROC) curve. Abnormal electrolytes were defined as chloride <100 mmol/L, bicarbonate ≥30 mmol/L or potassium >5.2 or <3.1 mmol/L. Maintenance fluid given was 5% dextrose in 0.45% saline with or without the addition of potassium dependent on the patient's potassium level and urine output. All patients were administered 1.5× maintenance fluids if abnormal electrolytes or urine output was present (<1 ml/kg/h). All boluses of fluid were given in the form of normal saline. It is our practice for labs to be drawn 1 h after the conclusion of a fluid bolus.

3. Results

During the study period 542 patients were identified with pyloric stenosis. Twenty six were excluded to owing to lack of data in the medical record. Eleven were analyzed separately as the electrolyte abnormalities were atypical for pyloric stenosis. Five-hundred five patients were analyzed. All surgeries were performed laparoscopically. Two-hundred two of these patients had electrolyte abnormalities requiring IV fluid resuscitation above maintenance, and 303 patients had normal electrolytes at time of diagnosis. Demographic data for these two groups are shown in Table 1.

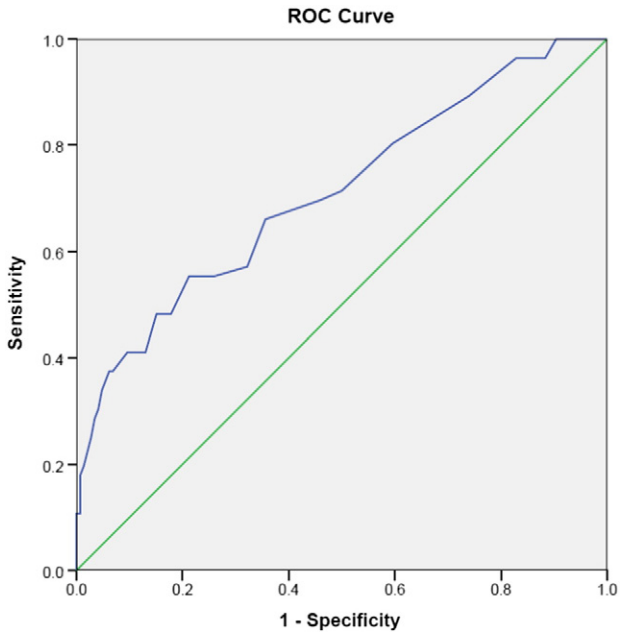

Fig. 1. ROC curve of the need for 3 or more 20 ml/kg saline boluses to normalize electrolytes if initial Cl^- <80 mmol/L.

Table 2
Initial Cl^- and need for saline boluses prior to electrolyte correction.

# of 20 ml/kg boluses	Cl^- value (mmol/L)	Sensitivity (%)	Specificity (%)	p	95% CI
	<70 (n = 5)	100	74.1	0.001	46–100
	<80 (n = 11)	90.9	75.9	<0.001	57–99
3	<85 (n = 26)	73.1	79	<0.001	52–88
	<90 (n = 49)	77	80.5	<0.001	63–87
	≤95 (n = 106)	71.7	44.8	0.02	62–80
2	≤97 (n = 132)	72.7	52.9	<0.001	64–80

Weight on presentation was significantly lower in the patients with abnormal electrolytes (Table 1). Total length of stay was significantly longer in the patients with electrolyte abnormalities, 2.6 vs 1.9 days ($p < 0.001$). Fluid given was higher over the entire hospital stay for patients with abnormal electrolytes (106 vs 91 ml/kg/d, $p < 0.001$). The number of electrolyte panels drawn was significantly higher in patients with initial electrolyte abnormalities, 2.8 vs 1.3 ($p < 0.001$). The current cost of basic metabolic panel is $105 at our institution. The total cost for basic metabolic panels in the patients with abnormal electrolytes was $59,388 versus $41,360 for those without electrolyte abnormalities. That difference is $18,000 despite the normal electrolyte group having 101 more patients. Average chloride value for patients with abnormal electrolytes was 93 ± 8.4 mmol/L. Twenty six patients presented with a normal chloride level (≥100 mmol/L) but an abnormal chloride level (≥30 mmol/L). Mean bicarbonate on presentation of patients with abnormal electrolytes was 32.5 ± 5.2 mmol/L. Thirty nine patients presented with normal bicarbonate level (<30 mmol/L) and an abnormal chloride level (<100 mmol/L).

Sixty four percent (130 of 202) of patients with abnormal electrolytes on presentation required multiple 20 ml/kg normal saline boluses. Both chloride (Cl^-) and bicarbonate (HCO_3) were useful markers in determining the number of 20 ml/kg normal saline boluses a patient would require prior to electrolyte normalization (Cl^- ≥100, HCO_3^-<30, K^+ ≥3.4 <5.2 mmol/L). Using a ROC curve, parameters of initial Cl <80 mmol/L and the need for 3 or more boluses AUC was 0.71 (Fig. 1). Modifying the parameters to initial Cl ≤97 mmol/L and 2 boluses AUC was 0.65. When initial $HCO_3 \le 33$ mmol/L and the need for 2 or more boluses are considered AUC was 0.66.

Sensitivity and specificity values correlated to variable values of both Cl^- and HCO^3 are shown in Tables 2 and 3. As seen in the tables, chloride is the more sensitive and specific electrolyte in the gauging the fluid resuscitation needs of a patient with pyloric stenosis. The total fluid required for correction of electrolytes based on initial chloride and bicarbonate values are shown in Figs. 2 and 3 with a linear regression model. Initial potassium value was not useful in guiding fluid resuscitation. Only 13.5% of patients presented with abnormal potassium not owing to hemolysis, 4.5% had a low value and 9.9% with an abnormally high value.

Eleven patients (2.2%) were found to have electrolyte abnormalities atypical for pyloric stenosis. All 11 patients were found to have a low bicarbonate level <22 mmol/L (mean 17.8 ± 1.9). Two patients were found to have an elevated chloride level (>111 mmol/L). Nine patients were found to have a normal chloride level on initial evaluation. Nine of eleven patients did receive at least one bolus of 20 ml/kg normal saline.

Table 3
Initial HCO_3 and need saline boluses prior to electrolyte correction.

# of 20 ml/kg boluses	HCO_3 value (mmol/L)	Sensitivity (%)	Specificity (%)	p	95% CI
	≥45 (n = 6)	83.3	72.7	0.009	36–99
3	≥40 (n = 19)	68.4	77	<0.001	43–86
	≥35 (n = 50)	82	41.4	0.003	68–91
	≥33 (n = 83)	77.1	44.5	0.002	66–85
2	≥31 (n = 126)	70.6	46.1	0.02	62–78