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Utility of Pyloric Length Measurement for Detecting Severe Metabolic Alkalosis in Infants with Hypertrophic Pyloric Stenosis

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The author has no financial conflicts of interest.

ABSTRACT

Purpose: Infantile hypertrophic pyloric stenosis (IHPS) is a common gastrointestinal disease in neonates and hypochloremia metabolic alkalosis is a typical laboratory finding in affected patients. This study aimed to analyze the clinical characteristics of infants with IHPS and evaluate the association of clinical and laboratory parameters with ultrasonographic findings.
Methods: Infants diagnosed with IHPS between January 2017 and July 2022 were retrospectively evaluated.
Results: A total of 67 patients were included in the study. The mean age at diagnosis was 40.5±19.59 days, and the mean symptom duration was 11.97±9.91 days. The mean pyloric muscle thickness and pyloric canal length were 4.87±1.05 mm and 19.6±3.46 mm, respectively. Hyponatremia and metabolic alkalosis were observed in five (7.5%) and 36 (53.7%) patients, respectively. Serum sodium (p=0.011), potassium (p=0.023), and chloride levels (p=0.015) were significantly lower in patients with high bicarbonate levels (≥30 mmol/L). Furthermore, pyloric canal length was significantly higher in patients with high bicarbonate levels (p=0.015). To assess metabolic alkalosis in IHPS patients, the area under the receiver operating characteristic curve of pyloric canal length was 0.910 and the optimal cutoff value of the pyloric canal length was 23.5 mm.
Conclusion: We found a close association between laboratory and ultrasonographic findings of IHPS. Clinicians should give special consideration to patients with pyloric lengths exceeding 23.5 mm and appropriate fluid rehydration should be given to these patients.

Keywords: Hypertrophic pyloric stenosis; Pyloric canal length; Metabolic alkalosis; Hyponatremia

INTRODUCTION

Infantile hypertrophic pyloric stenosis (IHPS) is a common gastrointestinal disease in neonates that is characterized by progressive projectile non-bilious vomiting [1]. Marked hypertrophy and hyperplasia of both the circular and longitudinal muscular layers of the pylorus are typical features of pyloric stenosis, and this thickening causes blockage of the gastric outlet and explosive vomiting after feeding [2]. The pyloric canal becomes lengthened

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and the mucosa becomes edematous and thickened. Therefore, a diagnosis can be made based on increased pyloric muscle thickness and canal length using abdominal ultrasonography [3]. The exact cause of smooth muscle cell hypertrophy is not well known [4].

Hypochloremia with metabolic alkalosis is a typical laboratory finding that results from the loss of gastric hydrochloric acid. A recent study reported a positive correlation between symptom duration and serum bicarbonate levels [5] and another study reported that pyloric muscle thickness is a significant factor for dehydration and high bicarbonate levels in infants with IHPS [6]. Normalization of metabolic derangement by fluid rehydration is important for avoiding complications after operation, such as apnea [7]. A recent retrospective review found that infants with preoperative respiratory problems were found to have significantly higher serum bicarbonate levels, with an odds ratio of 2.18 per 10 mmol/L and optimal bicarbonate cutoff level of 25.7 mmol/L [8]. Thus, it is important to recognize the high risk of metabolic derangement in infants; however, studies on this are scarce.

The aim of this study was to analyze the clinical characteristics of infants with IHPS and evaluate the associations of clinical and laboratory parameters with ultrasonographic findings.

MATERIALS AND METHODS

We retrospectively evaluated infants diagnosed with IHPS between January 2017 and July 2022. The following data were retrospectively collected by reviewing the clinical charts: demographic characteristics, laboratory, and sonographic findings. Demographic data included sex, gestational age, birth weight, weight at diagnosis, symptom duration, and frequency of vomiting in a day. Prematurity was defined as a gestational age <37 weeks. Laboratory evaluations included levels of total bilirubin and electrolytes. Weight loss was defined as weight loss at diagnosis when compared to weight at symptom onset.

Diagnosis of IHPS was based on clinical andultrasonographic findings. The ultrasonographic diagnostic criteria for IHPS were pyloric muscle thickening >4 mm and pyloric canal length >14 mm [9,10]. Once IHPS was diagnosed by abdominal ultrasonography, fluid treatment was required to normalize electrolytes until bicarbonate values declined to <30 mmol/L [11]. We divided the patients into two groups according to bicarbonate level and analyzed their clinical, laboratory and ultrasonographic findings. High bicarbonate groups were defined bicarbonate levels were over 30 mmol/L.

Continuous data are expressed as mean (±standard deviation). These were further compared using the Mann-Whitney U-test or Student's *t*-test. Discrete data are expressed as numbers and percentages and were compared using Fisher's exact or chi-square tests. The Pearson correlation coefficient was used to measure the strength of the linear relationship between pyloric canal length and serum bicarbonate level. Receiver operating characteristic (ROC) curves were plotted to illustrate the trade-off between specificity and sensitivity, identify adjusted cutoff values, and determine 95% confidence intervals (CIs). Statistical significance was set at $p<0.05$. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 24.0 (IBM Co.).

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This retrospective analysis was approved by the Institutional Review Board (IRB number: 2022-09-064). Informed consent was waived due to the retrospective nature of this study.

RESULTS

A total of 67 patients were included in the study. The mean age at diagnosis was 40.52±19.59 days, and the mean symptom duration was 11.97±9.91 days. Among 67 patients, 64 (95.5%) were full-term infants. The mean pyloric muscle thickness and pyloric canal length were 4.87±1.05 mm and 19.62±3.46 mm, respectively. Hyponatremia and metabolic alkalosis were observed in five (7.5%) and 36 (53.7%) patients, respectively. The mean sodium and bicarbonate levels were 137.61±2.82 mEq/L and 25.54±5.43 mmol/L, respectively. Postoperative vomiting was observed in 17 (25.4%) patients. The clinical characteristics and laboratory and ultrasonographic findings are summarized in **Table 1**.

Sixteen patients (23.9%) were found to have high serum bicarbonate levels. Serum sodium (p=0.011), potassium (p=0.023), and chloride (p=0.015) levels were significantly lower in patients with high bicarbonate levels than in patients with low bicarbonate levels. Furthermore, pyloric canal length was significantly higher in patients with high bicarbonate levels (23.65±2.76 vs. 18.56±2.74 mm, p=0.015) than in patients with low bicarbonate levels. Postoperative vomiting was frequently observed in patients with high bicarbonate levels. However, no differences were found in the symptom duration or weight at diagnosis between the two groups. Weight loss was more frequently observed in patients with high bicarbonate levels than in patients with low bicarbonate levels. The clinical characteristics according to serum bicarbonate levels are summarized in **Table 2**.

A significant positive correlation was found between pyloric canal length and serum bicarbonate level by Pearson correlation (R=0.585, p=0.015; **Fig. 1**).

Table 1. Clinical characteristics and laboratory and ultrasonographic findings of IHPS

Variable	Value (n=67)
Full term	64 (95.5)
Male	56 (83.6)
Birth weight (kg)	3.76±4.49
Age (d)	40.52±19.59
Symptom duration (d)	11.97±9.91
Frequency of vomiting (d)	3.76±1.32
Weight at diagnosis (kg)	4.41±0.88
Weight loss after symptom	18 (26.9)
Total bilirubin (mg/dL)	3.38±3.45
Electrolyte	
Sodium (mEq/L)	137.61±2.82
Potassium (mEq/L)	4.84±0.64
Chloride (mEq/L)	103.57±6.42
Bicarbonate (mmol/L)	25.54±5.43
Pyloric size	
Pyloric length (mm)	19.62±3.46
Muscle thickness (mm)	4.87±1.05
Postoperative vomiting	17 (25.4)

Values are presented as number (%) or mean±standard deviation.
IHPS: infantile hypertrophic pyloric stenosis.
Normal range for electrolyte, sodium: 135–145 mEq/L, potassium: 3.5–5.5 mEq/L, chloride: 97–110 mEq/L.

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Table 2. Clinical characteristics and laboratory and ultrasonographic findings of IHPS according to serum bicarbonate levels

Variable	Bicarbonate ≥30 mmol/L (N=16)	Bicarbonate <30 mmol/L (N=51)	*p*-value
Full term	16 (100.0)	48 (94.1)	0.526
Male	15 (93.8)	41 (80.4)	0.327
Birth weight (kg)	3.27±0.45	3.15±0.48	0.455
Age (d)	46.27±27.76	40.43±18.83	0.405
Symptom duration (d)	15.73±10.19	11.74±10.50	0.260
Frequency of vomiting (d)	4.18±1.32	3.72±1.41	0.321
Weight at diagnosis (kg)	4.24±0.74	4.52±0.97	0.352
Weight loss after symptom	8 (50.0)	10 (19.6)	0.006
Total bilirubin (mg/dL)	4.62±3.99	3.32±3.52	0.303
Electrolyte			
Sodium (mEq/L)	135.18±3.12	138.19±2.62	0.011
Potassium (mEq/L)	4.02±0.48	5.02±0.56	0.023
Chloride (mEq/L)	93.94±7.42	106.02±3.70	0.015
Pyloric size			
Pyloric length (mm)	23.65±2.76	18.56±2.74	0.015
Muscle thickness (mm)	4.90±0.95	4.91±1.15	0.452
Postoperative vomiting	8 (50.0)	9 (17.6)	0.017

Values are presented as number (%) or mean±standard deviation.
IHPS: infantile hypertrophic pyloric stenosis.
Normal range for electrolyte, sodium: 135–145 mEq/L, potassium: 3.5–5.5 mEq/L, chloride: 97–110 mEq/L.
Continuous data are compared using student's *t*-test and discrete data are compared using Chi-square tests.

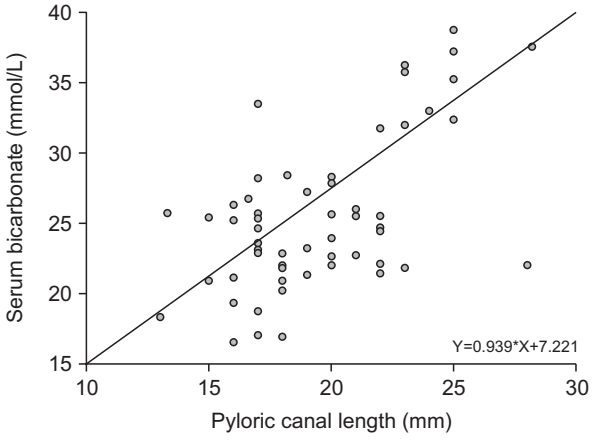

Fig. 1. Positive correlation between pyloric canal length and serum bicarbonate level (R=0.585, *p*=0.015).

To identify metabolic alkalosis with a high bicarbonate level, the area under the ROC curve for pyloric canal length was 0.910 (95% CI, 0.789–1.000). The optimal cutoff value of pyloric canal length was 23.5 mm. **Fig. 2** shows the ROC curve for prediction models to identify metabolic alkalosis in patients with high bicarbonate levels.

DISCUSSION

In this study, we evaluated the clinical characteristics of infants with IHPS and found a significant association between serum bicarbonate levels and pyloric canal length. The optimal cutoff pyloric canal length for detecting metabolic alkalosis in patients with a high bicarbonate level was 23.5 mm.

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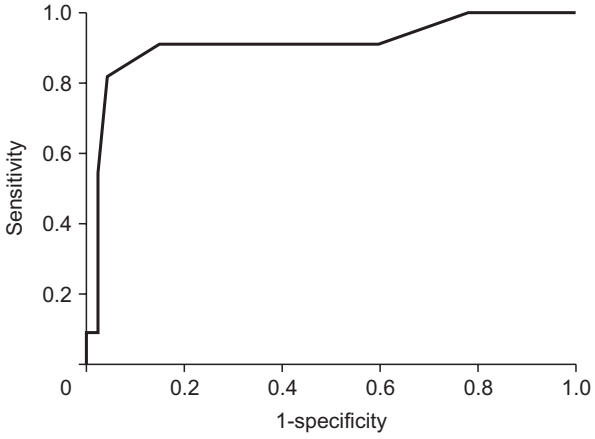

Fig. 2. Receiver operating characteristic curves for prediction models to distinguish subjects with metabolic alkalosis with high bicarbonate levels.

The ratio of both male and full-term infants was high, as was also found in a population-based study of IHPS [12]. The mean age at IHPS diagnosis and symptom duration were 40.5 days and 11.97 days, respectively, which were similar to other studies [13,14]. Delayed diagnosis can cause prolonged vomiting and lead to electrolyte derangement and metabolic alkalosis. Touloukian et al. [15] reported a two-fold longer vomiting duration in the higher bicarbonate group. However, in our study, symptom duration had no significant impact on biochemistry laboratory data.

Electrolyte disturbance and dehydration have been thought to be important predictors of poor outcomes after surgery and disease severity in IHPS [16,17]. Apnea or respiratory problems can also be caused by ventilatory drive inhibition in a severe alkalotic state [8]. Therefore, it is important to recognize IHPS early and treat it accordingly with fluid resuscitation [18]. In previous studies, ultrasonographic detection of increased pyloric muscle thickness was found to be associated with biochemical parameters, including metabolic alkalosis [6,19]. This relationship may be explained by persistent vomiting caused by gastric outlet narrowing due to increased muscle thickness. In our study, the mean pyloric muscle thickness and canal length were 4.87 mm and 19.6 mm, respectively; however, muscle thickness had no significant effect on metabolic alkalosis. We found a positive correlation between pyloric canal length and serum bicarbonate levels. These findings suggest that pyloric canal length can be a significant factor that determines the severity of laboratory presentations in IHPS.

Postoperative vomiting occurred in 17 (25.4%) patients, which was slightly higher than 11.8% found in a previous [16]. There were no other postoperative complications (including stricture) except postoperative vomiting, and pyloromyotomy was successfully completed in all patients. Studies investigating related factors for postoperative complications are rare; Graham et al. [20] showed that immediate feeding (up to 6hours postoperatively) resulted in more severepostoperative vomiting. In our study, reintroduction time for enteral feeding did not significantly affect the presence of postoperative vomiting, and the high bicarbonate group showed more frequent postoperative vomiting. The exact cause of the relationship between these two factors is not well known and future studies are needed to clarify this finding.

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Our study has several limitations. First, the sample size was too small to allow for definitive conclusions. Second, the retrospective study design may have affected the analysis variables. Despite these limitations, our study proposes an optimal ultrasonographic level for detecting high bicarbonate level sin IHPS, which will be valuable to clinicians.

In conclusion, we should be aware of the clinical significance of pyloric canal length for detecting sever metabolic alkalosis. A large well-designed prospective cohort study should be conducted to confirm our current findings.

REFERENCES

1. Peeters B, Benninga MA, Hennekam RCM. Infantile hypertrophic pyloric stenosis—genetics and syndromes. Nat Rev Gastroenterol Hepatol 2012;9:646-60. PUBMED | CROSSREF
2. Taylor ND, Cass DT, Holland AJA. Infantile hypertrophic pyloric stenosis: has anything changed? J Paediatr Child Health 2013;49:33-7. PUBMED | CROSSREF
3. Peters B, Oomen MW, Bakx R, Benninga MA. Advances in infantile hypertrophic pyloric stenosis. Expert Rev Gastroenterol Hepatol 2014;8:533-41. PUBMED | CROSSREF
4. Gezer H, Oguzkurt P, Temiz A, Hicsonmez A. Hypertrophic pyloric stenosis in twins; genetic or environmental factors. Clin Genet 2015;87:388-91. PUBMED | CROSSREF
5. Chuang YH, Chao HC, Yeh HY, Lai MW, Chen CC. Factors associated with pyloric hypertrophy severity and post-operative feeding and nutritional recovery in infantile hypertrophic pyloric stenosis. Biomed J 2022;45:948-56. PUBMED | CROSSREF
6. AlMaramhy HH. Is there a relation between pyloric muscle thickness and clinical and laboratory data in infants with hypertrophic pyloric stenosis? Indian J Surg 2015;77:827-30. PUBMED | CROSSREF
7. 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. Paediatr Anaesth 2020;30:749-58. PUBMED | CROSSREF
8. van den Bunder FAIM, van Woensel JBM, Stevens MF, van de Brug T, van Heurn LWE, Derikx JPM. Respiratory problems owing to severe metabolic alkalosis in infants presenting with hypertrophic pyloric stenosis. J Pediatr Surg 2020;55:2772-6. PUBMED | CROSSREF
9. Hussain M. Sonographic diagnosis of infantile hypertrophic pyloric stenosis-use of simultaneous grey-scale & colour doppler examination. Int J Health Sci (Qassim) 2008;2:134-40. PUBMED
10. Zaghal A, El-Majzoub N, Jaafar R, Aoun B, Jradi N. Brief overview and updates on infantile hypertrophic pyloric stenosis: focus on perioperative management. Pediatr Ann 2021;50:e136-41. PUBMED | CROSSREF
11. Rich BS, Dolgin SE. Hypertrophic pyloric stenosis. Pediatr Rev 2021;42:539-45. PUBMED | CROSSREF
12. Vermes G, Mátrai Á, Czeizel AE, Ács N. Birth outcomes of male and female patients with infantile hypertrophic pyloric stenosis--a population-based case-control study. J Matern Fetal Neonatal Med 2016;29:1777-82. PUBMED | CROSSREF
13. Huang IF, Tiao MM, Chiou CC, Shih HH, Hu HH, Ruiz JP. Infantile hypertrophic pyloric stenosis before 3 weeks of age in infants and preterm babies. Pediatr Int 2011;53:18-23. PUBMED | CROSSREF
14. Mcheik JN, Dichamp I, Levard G, Ragot S, Beby-Defaux A, Grosos C, et al. Infantile hypertrophic pyloric stenosis: are viruses involved? J Med Virol 2010;82:2087-91. PUBMED | CROSSREF
15. Touloukian RJ, Higgins E. The spectrum of serum electrolytes in hypertrophic pyloric stenosis. J Pediatr Surg 1983;18:394-7. PUBMED | CROSSREF
16. Chalya PL, Manyama M, Kayange NM, Mabula JB, Massenga A. Infantile hypertrophic pyloric stenosis at a tertiary care hospital in Tanzania: a surgical experience with 102 patients over a 5-year period. BMC Res Notes 2015;18:690. PUBMED | CROSSREF
17. 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;55:1183-7. PUBMED | CROSSREF
18. Williams T, Cosgrove M. Evaluation of vomiting in children. Paediatr Child Health 2012;22:419-25. CROSSREF
19. Ulusoy O, Aydın E, Karakurt AG. Evaluation of risk factors affecting metabolic alkalosis in infantile hypertrophic pyloric stenosis. J Tepecik Educ Res Hosp 2022;32:273-8. CROSSREF

20. Graham KA, Laituri CA, Markel TA, Ladd AP. A review of postoperative feeding regimens in infantile hypertrophic pyloric stenosis. J Pediatr Surg 2013;48:2175-9. PUBMED | CROSSREF