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Research Article

Pyloric Muscle Measurements and Serum Electrolyte Correlations in Infants with Hypertrophic Pyloric Stenosis: Clinical Insights from a Single-Center Study in Saudi Arabia

Tuqa Alsinan[1]*, Razan Alnujaidi[2], Abdullah A Al Qurashi[3], Sarah W Alkhonizy[4], Nawra Alsinan[4], Noureen Almasoud[4], Mariyyah Al Jamea[5], Ahmed Abdulaziz Alqerafi[6] and Abdulwahab AlJubab[7]

[1]Pediatric Surgery Resident, College of Medicine, Department of Pediatric Surgery, Alfaisal University, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

[2]Pediatric Surgery Resident, Pediatric Surgery Department, King Fahad Medical City, Riyadh, Saudi Arabia

[3]College of Medicine, King Saud bin Abdulaziz University for Health Sciences at the National Guards, King Abdullah International Medical Research Center, Jeddah, Saudi Arabia

[4]College of Medicine, Alfaisal University, Riyadh, Saudi Arabia

[5]College of Medicine, King Faisal University, Alhafouf, Saudi Arabia

[6]King Saud bin Abdulaziz for Health Sciences, Jeddah, Saudi Arabia

[7]Consultant, Pediatric Surgeon, Chairman, Pediatric Surgery Department, King Fahad Medical City, Riyadh, Saudi Arabia

***Corresponding Author:** Tuqa Alsinan, Pediatric Surgery Resident, College of Medicine, Department of Pediatric Surgery, Alfaisal University, Prince Sultan Military Medical City, Riyadh, Saudi Arabia.

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Abstract

Background: HPS is a common obstruction in infants, necessitating an in-depth analysis of demographic profiles and surgical outcomes for effective management. This study aimed to investigate the clinical insights of pyloric muscle measurements and serum electrolytes during the practice within a tertiary hospital setting, utilizing a convenient sample size for analysis.

Results: Infants predominantly male with HPS presented with an average weight of 3.487 ± 0.886 kg and experienced an average hospital stay of 47.87 ± 74.18 days. Following pyloric muscle correction, 40% of infants gradually resumed feeding, while 40% immediately accepted oral intake. Significant correlations were observed between pyloric muscle dimensions, presentation weight, and duration from birth to admission. Serum Na and K levels exhibited positive correlations, while serum Cl displayed a negative association with the duration from birth to admission.

Conclusion: This study offers detailed insights into the demographic characteristics, clinical presentation, and surgical outcomes of infants with HPS undergoing pyloromyotomy. These findings contribute to a better understanding of HPS management in infants, warranting further investigation through larger-scale studies for validation.

Keywords: Hypertrophic Pyloric Stenosis; Pyloromyotomy; Pyloric Muscle Measurement; Serum Electrolyte; Single-Center; Pediatric Surgery

Abbreviation

HPS: Hypertrophic Pyloric Stenosis; US: Ultrasound

Introduction

Hypertrophic Pyloric Stenosis (HPS) stands as a primary cause of gastric outlet obstruction in infancy, typically manifesting between 3 to 5 weeks of age and seldom occurring after 12 weeks [1]. The global incidence of HPS ranges from 2-4 cases per 1000 live births, albeit showing a decline in some regions [2]. Locally, in Saudi Arabia, the estimated incidence rate rests at 1.4 cases per 1000 live births [3], with a noteworthy male predominance at a ratio of

four to one [1]. The underlying pathophysiology of gastric outlet obstruction in HPS involves hyperplasia and hypertrophy of the pyloric muscles [2]. Infants afflicted with pyloric stenosis typically present clinical features including nonbilious projectile vomiting, dehydration, and hypokalemic hypochloremic metabolic alkalosis [2,3]. Before surgical intervention, resuscitation and correction of any associated laboratory imbalances are crucial.

Various clinical parameters such as age, family history, vomiting characteristics, antibiotic use (Macrolides and Erythromycin), mode of delivery (cesarean-section), and feeding method (bottle feeding) are pertinent in evaluating the patient's clinical status [1,2]. Ultrasound imaging aids in determining the precise sphincter thickness, a diagnostic method employed since 1977 [3]. The gold standard for treatment remains a pyloromyotomy or Ramstedt Procedure, performed since 1911 [4], which can be executed via open or laparoscopic techniques, both proven to be safe and effective [4]. Although hypotheses suggest demographic, clinical, and biochemical profile changes impacting HPS outcomes, studies such as that by Kumar., *et al.* reveal otherwise [5]. Additionally, investigations into surgical outcomes concerning the center's quality and volume did not exhibit a significant relationship with the overall outcome for infants with HPS [6,7].

Despite the limited number of cases, our study at a tertiary center in Riyadh, Saudi Arabia, has allowed us to closely monitor a considerable cohort of infants with HPS who underwent surgical procedures. Notably, we observed satisfactory surgical outcomes employing preferred methods, underscoring the potential relevance of our findings in the management of HPS cases at the national level.

Patients and Methods

Study design and setting

The authors conducted a retrospective single-center study of 26 infants diagnosed with HPS and underwent pyloromyotomy procedures between June 2012 and June 2022 at a tertiary center in Riyadh, Saudi Arabia. Electronic data and written medical records, including transfer notes from other hospitals, were reviewed and analyzed. Data were included if the patient was diagnosed with HPS and underwent pyloromyotomy, and whether the patient had symptoms, signs, biochemical changes, or radiological features of HPS. Patients who did not experience a pyloromyotomy, had not been discharged from the hospital between birth and the pyloromyotomy, or were intra-operatively found not to have HPS were excluded from the study. Moreover, The collected data included patients' demographics: date of birth and weight at presentation, date of admission to the tertiary center, preoperative information, including the detailed Ultrasound (US) findings upon admission consisting of the pyloric muscle length, thickness, and diameter, in addition to the blood gas results before the administration of fluid resuscitation, operative information, including the surgical approach, intraoperative findings, and complications, date of discharge, and time of first postoperative feed.

Statistical analysis

The data were cleaned, coded, and then analyzed using Statistical Packages for Social Sciences (SPSS) version 26 Armonk, NY: IBM Corp. The demographic traits of the included patients in the study were presented as mean, frequency, and percentages. The Pearson correlation test was used to assess the linear relationship between different continuous variables. The test calculated the correlation coefficient (r), which measures the strength and direction of the linear relationship between two variables. The p-value associated with the correlation coefficient measures the probability of obtaining the observed correlation coefficient by chance, assuming no correlation exists between the two variables. Both were reported, and a p-value of less than 0.05 was considered significant.

Results

This study reviewed data from 26 infants diagnosed with pyloric stenosis at a tertiary hospital with high volume in Riyadh, Saudi Arabia. The cohort predominantly comprised male infants (34.5%), with a mean weight at presentation of 3.487 ± 0.886 and an average hospital stay of 47.87 Days ± 74.18 Days. The US evaluations of the cohort revealed specific measurements: pyloric muscle length (19.86 ± 4.11), wall diameter (31 ± 13.05), and thickness (4.05 ± 2.17). During surgery, observations of pyloric muscles named differently included hypertrophied pylorus in 33.3% of patients, pyloric olive in 13.3%, and similar findings described variably as a pyloric mass in 26.8% of cases. Post-pyloric muscle correction, 40% of patients gradually resumed feeding, while 40% were able to tolerate oral feeding immediately post-op. Detailed information is provided in table 1.

Variable	Category	Data
Gender	Male	23 (34.5%)
	Female	3 (65.4%)
Weight at presentation	Mean ± Standard Deviation	3.487 ± 0.886
Length of stay in hospital	Mean	47.87 Days
	Standard Deviation	74.18 Days
	Maximum	35 Days
	Minimum	2 Days
Pyloric Muscle Length in Ultrasound (Millimeter)	Mean	19.86
	Standard Deviation	4.11
	Maximum	24
	Minimum	9
Pyloric Muscle Thickness in Ultrasound (Millimeter)	Mean	4.05
	Standard Deviation	2.176
	Maximum	15
	Minimum	2
Pyloric Muscle Wall Diameter in Ultrasound (Millimeter)	Mean	31
	Standard Deviation	13.05
	Maximum	48
	Minimum	15
Intraoperative Findings	Hypertrophied pylorus	5 (33.3%)
	Pyloric olive	2 (13.3%)
	Thickened pylorus	1 (6.7%)
	Dilated stomach with hypertrophied pylorus	1 (6.7%)
	Hypertrophied pylorus with pyloric stenosis	1 (6.7%)
	Pyloric mass identified	1 (6.7%)
	Others*	2 (13.4%)
Postoperative Oral Intake	Resumed feeding gradually after surgery	10 (40%)
	Tolerated oral feeding post-op	10 (40%)
	Others**	6 (20%)

Table 1: General characteristics of the included patients (N = 26).

Moreover, the analysis of serum electrolyte levels in the cohort revealed mean values: Sodium (Na) 140.16 ± 3.23, Chloride (Cl) 100.84 ± 10.69, Potassium (K) 4.42 ± 0.804, and Bicarbonate (HCO3) 23.1 ± 7.9. Further details can be found in table 2.

Variable	Category	Data
Serum Na (Sodium) (Normal Range 135-145 mmol/L.)	Mean	140.16
	Standard Deviation	3.23
	Maximum	147
	Minimum	135
Serum Cl (Chloride) (Normal Range 96-106 mmol/L.)	Mean	100.84
	Standard Deviation	10.69
	Maximum	121
	Minimum	79
Serum K (Potassium) (Normal Range 3.5-5.0 mmol/L)	Mean	4.42
	Standard Deviation	0.804
	Maximum	5.9
	Minimum	3.4
Serum HCO3 (Bicarbonate) (Normal Range 22-28 mmol/L	Mean	23.1
	Standard Deviation	7.9
	Maximum	11.1
	Minimum	37.2

Table 2: Serum levels of Sodium, Chloride, Potassium, and Bicarbonate of the included patients (N = 26).

Additionally, correlation analyses were conducted between various pyloric muscle measurements, serum electrolyte levels, and demographic variables. Notable findings included a positive correlation between pyloric muscle length and the duration between birth and admission ($r = 0.207$, $p = 0.360$), as well as weight at presentation ($r = 0.20$, $p = 0.45$). Meanwhile, muscle thickness exhibited a positive correlation with the duration between birth and admission ($r = 0.013$, $p = 0.006$*), but a negative correlation with weight at presentation ($r = -0.214$, $p = 0.042$*). The diameter was positively correlated with weight at presentation ($r = 0.249$, $p = 0.330$). Serum electrolyte correlations demonstrated Na positively correlating with the duration between birth and admission ($r = 0.194$, $p = 0.384$), while Cl showed a negative correlation with this

duration (r = -0.154, p = 0.377). HCO3 displayed negative correlations with several factors, including the duration between birth and admission (r = -0.283, p = 0.042), weight at presentation (r = -0.400, p = 0.003), pyloric muscle length, thickness, and wall diameter. K exhibited a positive correlation with the duration between birth and admission (r = 0.087, p = 0.634). Further details are outlined in table 3.

Variable	Correlated to	p-value	r value
Pyloric Muscle Length in Ultrasound (Millimeter)	Difference between the birth date until admission	0.360	0.207
	Weight at presentation	0.45	0.20
Pyloric Muscle Thickness in Ultrasound (Millimeter)	Difference between the birth date until admission	0.006*	0.013
	Weight at presentation	0.042*	-0.214
Pyloric Muscle Wall Diameter in Ultrasound (Millimeter)	Difference between the birth date until admission	0.51	0.164
	Weight at presentation	0.330	0.249
Serum Na (Sodium)	Difference between the birth date until admission	0.384	0.194
	Weight at presentation	0.638	-0.098
	Pyloric Muscle Length	0.327	-0.229
	Pyloric Muscle Thickness	0.772	-0.069
	Pyloric Muscle Wall Diameter	0.033*	0.702
Serum Cl (Chloride)	Difference between the birth date until admission	0.377	-0.154
	Weight at presentation	0.563	-0.131
	Pyloric Muscle Length	0.327	-0.229
	Pyloric Muscle Thickness	0.215	-0.214
	Pyloric Muscle Wall Diameter	0.242	-0.312
Serum HCO3 (Bicarbonate)	Difference between the birth date until admission	0.042	-0.283
	Weight at presentation	0.003*	-0.400
	Pyloric Muscle Length	0.009*	-0.359
	Pyloric Muscle Thickness	0.028*	-0.308
	Pyloric Muscle Wall Diameter	0.025*	-0.313
Serum K (Potassium)	Difference between the birth date until admission	0.634	0.087
	Weight at presentation	0.383	-0.163
	Pyloric Muscle Length	0.503	-0.117
	Pyloric Muscle Thickness	0.659	0.078
	Pyloric Muscle Wall Diameter	0.387	0.161

Table 3: Pearson correlation test of general patients' characterises (N = 26).

Discussion

This retrospective study conducted at a leading Saudi Arabian hospital analyzed infants diagnosed with HPS to gain insights into presentation and clinical outcomes. The observed male predominance in this cohort aligns with previous reports, as pyloric stenosis tends to affect males more than females [8], with a male-to-female ratio ranging from 4:1 to 6:1 [9]. This finding is consistent with other studies from the Middle East region, such as a retrospective review from Iran that reported a male-to-female ratio of 5.6:1 in their cohort of 193 infants with pyloric stenosis [21]. The exact cause of this gender disparity remains unclear, but hormonal or genetic factors, including potential exposure to elevated intrauterine testosterone levels, have been postulated [10,11].

The cohort's average weight at presentation (3.487 ± 0.886) might reflect the severity and duration of vomiting, coupled with individual growth rates [12]. Early identification and management of pyloric stenosis are critical in preventing significant weight loss and dehydration, ensuring better outcomes for affected infants [13,14]. This is corroborated by a study from the United States that found infants with pyloric stenosis had a mean weight loss of 8.4% prior to surgical intervention [22]. Prompt diagnosis and treatment are essential to minimize the detrimental effects of prolonged vomiting and weight loss in these patients.

Moreover, the prolonged average hospital stay (47.87 Days ± 74.18 Days) underscores the potential risks associated with extended hospitalizations, including increased infections, complications, elevated healthcare expenses, reduced quality of life, and diminished functional capacity [15]. This is in line with findings

from a study in India, which reported an average length of hospital stay of 42 days for infants with pyloric stenosis [23]. Efforts to minimize hospital stays in pediatric patients should be prioritized by surgeons, as seen in a study from the United Kingdom that implemented enhanced recovery protocols and reduced the median length of stay from 5 days to 3 days [24].

The US-derived measurements of pyloric muscle length (19.86 ± 4.11), diameter (31 ± 13.05), and thickness (4.05 ± 2.17) in our study corroborate findings from previous literature [16-20]. These parameters are crucial for diagnosing pyloric stenosis, with established standards for muscle wall diameter (12 to 16 mm), muscle thickness (2 to 3 mm), and muscle length (14 to 18 mm) [16-20]. Similar findings have been reported in studies from other geographical regions, such as a retrospective analysis from China that found mean pyloric muscle length, diameter, and thickness of 19.9 ± 3.1 mm, 15.1 ± 3.1 mm, and 3.6 ± 1.0 mm, respectively [25].

While this study offers valuable insights, several limitations must be acknowledged. Its retrospective nature may entail missing or inaccurately documented data, as seen in a systematic review that highlighted the challenges of data completeness in retrospective studies of pyloric stenosis [26]. Additionally, the study's single-center design might limit generalizability, and the relatively small sample size could affect statistical power and precision, as noted in a multi-center study from the United States with a larger cohort of 1,265 infants [27]. Confounding variables, not accounted for due to the retrospective approach, could have influenced the results, a common issue in retrospective studies as discussed in a review article on the topic [28].

To address these limitations, future studies should consider prospective designs to minimize data gaps or errors and incorporate larger, multi-center cohorts for broader generalizability, as demonstrated in a multicountry, prospective study on pyloric stenosis epidemiology [29]. Additionally, controlling for confounding variables in future investigations will enhance result reliability, as seen in a case-control study that examined the impact of various risk factors on the development of pyloric stenosis [30]. Long-term outcome studies on infants with pyloric stenosis, including assessments of gastroesophageal reflux disease incidence and the necessity for subsequent surgical interventions, warrant exploration to provide a more comprehensive understanding of the condition and its implications.

Conclusions

This study aimed to highlight the insights of a tertiary center with high volume in Riyadh, Saudi Arabia by reviewing and investigating the correlations between pyloric muscle measurements and serum electrolytes. Early recognition and management are crucial to prevent weight loss and dehydration, emphasizing the need for shorter hospital stays. These findings guide clinicians in HPS diagnosis and management, urging further research for confirmation and standardized approaches, understanding the current practice and assessment in such cases, and advocating for larger or multicenter studies in Saudi Arabia for a comprehensive understanding and improved patient care.

Declarations

- **Ethical Approval and Consent to Participate:** Not applicable.
- **Consent for Publication:** Not applicable.
- **Availability of Data and Materials:** Not applicable
- **Competing Interests:** The authors declare that they have no competing interests.
- **Funding**: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
- **Authros' contributions:** TS and AJ designed and created the methods of the study based on experience and a literature review of this disease. TS submitted the proposal and received IRB approval from the institution committee. RN, AQ, NM, SK, NS, MJ, and AQI drafted the data sheet and collected and interpreted the data. TS and AQ analyzed and wrote the results. SK and NS reviewed the literature and drafted the discussion section. MJ reviewed and finalized the manuscript file.
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